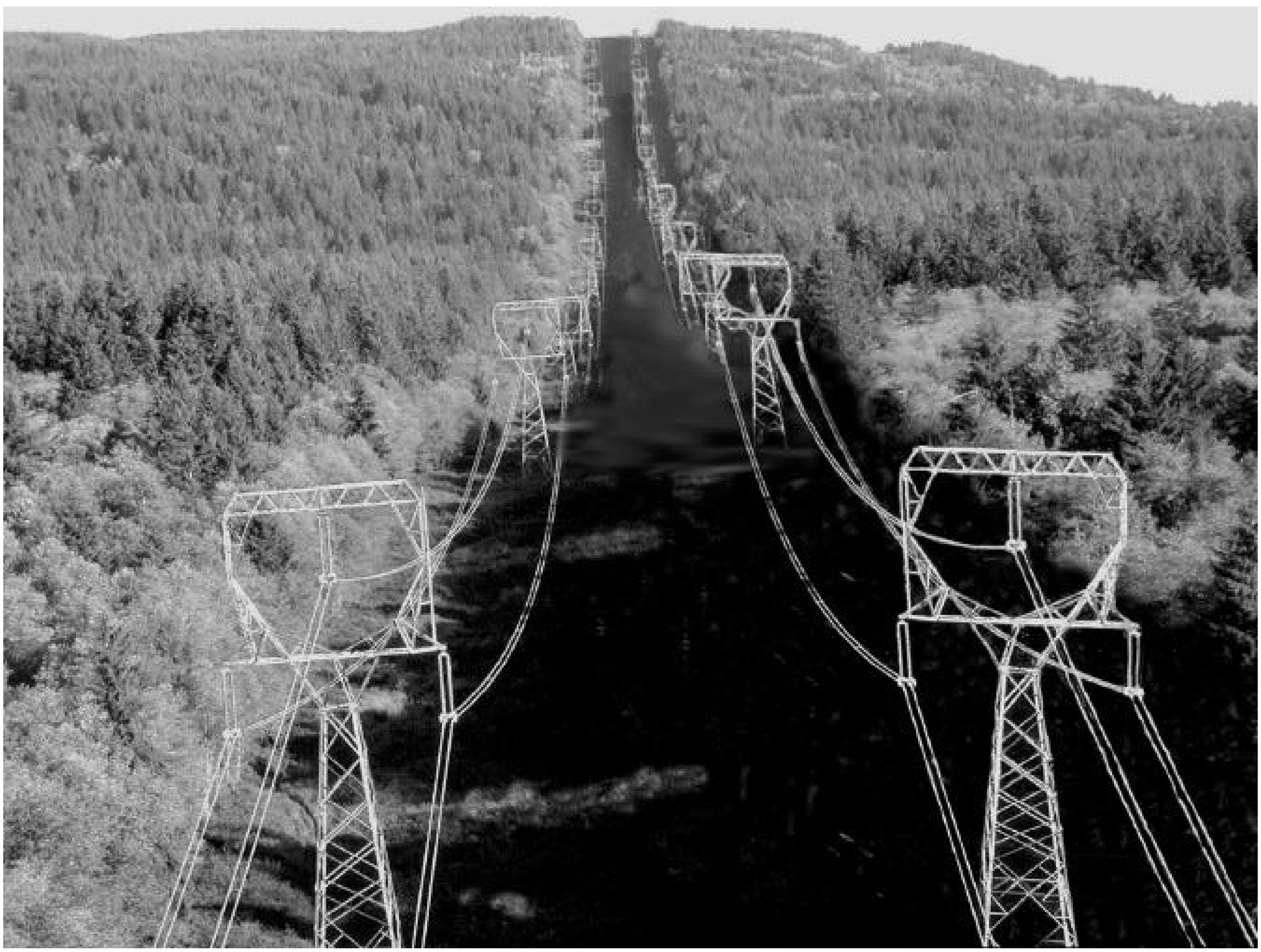
JUNE 2003

KANGLEY - ECHO LAKE TRANSMISSION LINE PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT - APPENDICES

DOE/EIS-0317-S1



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Appendices

Addition to Appendix A Final Fisheries Technical Report

Appendix A.

Data and Comments for Streams, Map and Aerial Photo-Based Surveys

Appendix A.

Table A-1. Data and comments for streams, map and airphoto-based survey.

Stream name	Number	KC Class[1]	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Cedar River	1	I	Conifers	C	Rainbow, Cutthroat	None	Kokanee, Steelhead, Chinook, Coho, Sockeye, Bull trout		WDF 1975, CRW, SN2000	Above Landsburg Dam	20	300	140' tall PSME, THPL >14" dbh border stream	Clearing may be avoidable given that trees exist within RMZ of existing transmission line. Proposed alignment will intersect.
Trib to Rock Creek	2	II	Conifers w/ a thin line of hardwoods adjacent to creek & existing transmission line.	D	Rainbow, Cutthroat	None	Steelhead, Coho		WDF 1975	Above Landsburg Dam, Falls Downstream (WDF 1975). Potential anadromous habitat (CRW)	82	300	PSME, THPL, TSHE and 70-90' tall ALRU	Proposed alignment will intersect. Clearing appears to be necessary.
Rock Creek	3	II	Conifers w/ some hardwoods.	D	Rainbow, Cutthroat	None	Steelhead, Coho		SN2000, WDF 1975	Above Landsburg Dam, falls downstream (WDF 1975), Potential anadromous habitat (CRW). Gradient ~20%.	80	300	PSME,TH PL< TSHE, ALRU 70-90' tall	Tall conifers present under existing transmission line. Tributary and existing veg. Located w/n canyon.
Trib to Raging River	4	II	Conifers	D	Rainbow, Cutthroat	None	None		WDF 1975	Cascades block passage (WDF 1975). Raging river 3000 feet downstream.	85	300	Conifers.	Tall conifers present under existing transmission line. Tributary and existing veg. Located w/n canyon. Proposed alignment will intersect.
Trib to Deep Creek	5	II	Primarily hardwoods w/ some conifers	D	Rainbow, Cutthroat	None	None		WDF 1975	Cascades block passage (WDF 1975). Steelhead 5000 feet downstream.	95	200	Mixed forest.	Hardwood (ALRU) dominated RMZ.

Stream name	Number	KC Class[1]	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Trib to Raging River	6	II		D	Rainbow, Cutthroat	None	Coho, Steelhead		WDF 1975, SN 2000	Steelhead and Coho 1000' downstream in Raging River.	70	300	Mixed forest	
Raging River	7	I	Conifers w/ occasional hardwoods (most likely alder).	D	Rainbow, Cutthroat	Rainbow, Cutthroat	Coho, Steelhead	Coho, Steelhead, Chinook	SN2000, WDF 1975	ROW crosses Raging River 5000' upstream of Chinook Spawning area.	75	150	PSME, THPL, PICI 14-35" dbh. Heights variable 80-120'	To the east of ROW: South of Raging River is clearcut for 800'. 35-40' tall PSME borders ROW for the next 3500' south. 14-35" DBH trees border the Raging River in a 150' swath along the River; due to deep canyon, clearing may be avoidable.
Trib to Raging River	8	II	No buffer of large trees.	D	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	>20% gradient to Raging River 2500 feet downstream.	30	50	Young ALRU. PSME	Clearcut with 10 year old PSME bordering stream. 15' tall ALRU within the RMZ provide shade.
Unnamed channel	9	II		E	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	No connection to anadromous streams	0	0	Shrub/herbaceous	New road crossing location
Unnamed channel	10	II	Deciduous shrubs/herbaceous spp., w/ few conifers (less than 20)	E	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	No connection to anadromous streams. Appears to be non-fish bearing.	50	25	PSME and ALRU	Young deciduous shrubs and PSME regen. New road crossing location.
Cedar River	11	I	Conifers w/ hardwoods adj. to river bed	G	Rainbow, Cutthroat	None	Coho, Steelhead, Chinook, Bull trout, Kokanee		SN2000, WDF 1975	Above Landsburg Dam.	20	300	70 year old PSME, TSHE, PTHP 16-28" tall	Road corridors on north and south side of river. Proposed Option 2 would intersect river. Clearing necessary.
Unnamed channel	19	II		J	Rainbow, Cutthroat	None	None		WDF 1975	No connection to anadromous	20	0	Young deciduous, shrub and PSME regen.	NEW ROAD CROSSING LOCATION.

Stream name	Number	KC Class[1]	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Unnamed channel	20	II	Conifers w/ some hardwoods.	J	Rainbow, Cutthroat	None	None		WDF 1975	No connection to anadromous. Associated with wetland complex within Green River Watershed.	60	125	20" dbh THPL, TSHE	NEW ROAD CROSSING LOCATION.
Taylor Creek	21	II	Conifers on NW & S side of Pole Line Rd. Hardwoods on SW side.	J	Rainbow, Cutthroat	None	None		WDF 1975	Cascades barrier to anadromous (WDF 1975).	40	300	Mixed forest	Coniferous spp. on NW side of Pole Line Rd. Deciduous spp. On SW side. Conifers on south side of road. Proposed ROW intersects; clearing appears necessary.
Cedar River	22	I	Conifers	J	Rainbow,. Cutthroat	None	Chinook, Coho, Steelhead, Bull trout, Sockeye		WDF 1975	Above Landsburg Dam.	35	300	Mixed forest	Cutting required due to floodplain topography; proposed ROW would intersect.
Steele Creek	23	II		J	Rainbow, Cutthroat	None	None		WDF 1975	Barrier at Holamar Road (WDF 1975)	75	300	Mixed forest and road	NEW ROAD CROSSING LOCATION.
Trib to Steele Creek	23.1	II			Rainbow, Cutthroat	None	None			Barrier at Holamar Road downstream (WDF 1975)	60	30	Mixed young forest.	NEW ROAD CROSSING LOCATION.
Steele Creek	24	II	Interspersed hardwoods & conifers.	J	Rainbow, Cutthroat	None	None		WDF 1975	Barrier at Holamar Road (WDF 1975)	40	30	Mixed young forest. Existing road compromises shade.	
Trib to Steele Creek	25	II	Conifers	J	Rainbow, Cutthroat	None	None		WDF 1975	Barrier at Holamar Road (WDF 1975).	30	30	Mixed young conifer forest. Wetland	Clearing most likely avoidable; intersects proposed ROW.
Trib to Raging River	26	II		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	Raging River 4000' downstream. Steelhead documented 1000' downstream.	60	60	Mixed 60' tall PSME and ALRU	NEW ROAD CROSSING LOCATION.

Stream name	Number	KC Class[1]	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Trib to Raging River	27	II		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	Raging River 4000' downstream. Steelhead documented 1000' downstream.	65	50	Mixed 60' tall PSME and ALRU	NEW ROAD CROSSING LOCATION.
Upper Raging River	28	II		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	Chinook spawn more than 3.5 miles downstream. (In Raging River upper watershed). Steelhead barrier about 1000' downstream.	90	75	Mixed forest. 10-20" dbh TSHE, PSME, ALRU, POBA	
Trib to Raging River	29	II		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Raging River 2500' downstream. Cascades barrier and >20% downstream.	95	300	47' tall PSME and ALRU (8" dbh) border stream	
Trib to Raging River	30	II		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Steelhead 300+' downstream. Cascades barrier (WDF 1975)	95	300+	56' tall PSME 11" dbh	High density PSME borders stream. NEW ROAD CROSSING LOCATION.
Trib to Raging River	31	II		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Steelhead 500' downstream. Cascades barrier (WDF 1975)	95	300+	56' tall PSME 11" dbh	High density PSME borders stream.
Trib to Raging River	32	II		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Cascade barrier downstream, watershed < 50 acres	0	NA	Shrub/herbs	
Trib to Raging River	33	II		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Cascade barrier downstream, watershed < 50 acres	0	NA	Shrub/herbs	

Stream name	Number	KC Class[1]	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Trib to Raging River	34	II		J	Rainbow, Cutthroat	None	None		WDF, 1975	Raging River 1500' downstream. Cascades barrier (WDF 1975)	50	70'	35-40' tall PSME, ALRU 6" dbh	
Trib to Raging River	35	II		J	Rainbow, Cutthroat	None	None		WDF 1975	Cascade barrier downstream	50	90	50 year old TSHE/THPL and 35-40' tall ALRU/PSME border stream	
Canyon Creek (Trib to Raging River)	36	II		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	12% grade to Raging River ~2000' downstream.	75	100	15-20" dbh TSHE, THPL border stream.	
Trib to Raging River	37	II		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River ~2000' downstream. Coho and Steelhead 2000' downstream. Cascade Barrier	0	NA	Shrub/herbs	
Trib to Raging River	38	II		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River and associated Coho and Steelhead 2000' downstream. Cascade barrier.	0	NA	Shrub/herbs	
Trib to Raging River	39	II		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River 2000' downstream. Cascade barrier.	60	50	12-14" dbh conifers border stream in narrow swath	ALRU and shrubs also provide shade to stream.
Trib to Raging River	40	II		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River 2000' downstream. Cascade barrier.	0	NA	Shrub/herbs	Clearcut. (shrubs and herbs may provide shade).

Stream name	Number	KC Class[1]	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Cedar River Riparian Area	43	II	Conifers	H	Rainbow, Cutthroat	None	Chinook, Coho, Kokanee, Bull trout, Steelhead		WDF 1975, Seattle 1998, SN2000		65	300+	140' tall PSME >14 " dbh border stream	Conifers border river on both sides. Riparian zone encroachment on south side of Cedar River. Proposed 4A parallels Cedar River for ~1000'. Clearing nec because of flat terrain.

[1] King County Code Chapter 6 of Title 21A

References:

WDF 1975 = Washington Department of Fisheries. 1975. A catalog of Washington streams and salmon utilization. Volume 1, Puget Sound.
Seattle 1998 = City of Seattle, Cedar River Watershed Habitat Conservation Plan.
SN2000 = www.Streamnet.org, data accessed November, 2000.

Appendix D Final Wetlands Technical Report

Final Wetlands Technical Report

Bonneville Power Administration Kangley-Echo Lake Transmission Project

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April 2003

The analysis in this technical report is generally based on typical construction activities and impacts for transmission lines. Detailed information for this project has been updated as much as possible. However, the most current information about this project is in the Final Environmental Impact Statement.

This document should be cited as:

Jones & Stokes. 2003. Bonneville Power Administration Kangley-Echo Lake Transmission Project. Final wetlands technical report. April. (JSA 0P005.00.) Bellevue, WA. Prepared for Bonneville Power Administration, Portland, OR.

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List of Tables and Figures

1.0 Executive Summary

This report describes the existing conditions and potential impacts on vegetation from the proposed Bonneville Power Administration (BPA) Kangley-Echo Lake Transmission Line Project. This report serves as the primary basis for the vegetation discussion in the National Environmental Policy Act (NEPA) environmental impact statement (EIS) prepared for the project.

1.1 Alternatives

This EIS evaluates five alternative routes for constructing a new 500-kilovolt (kV) electrical transmission line intended to increase the reliability of the Seattle metropolitan area's transmission system. This increased reliability would reduce the potential for rolling brownouts or blackouts that could transpire by the winter of 2002-2003 if the current rate of development continues and if severe winter weather were to cause inordinate power demand.

The transmission line would start at the Schultz-Raver No. 2 500-kV transmission line near the unincorporated community of Kangley in central King County, Washington and travel approximately 9 miles (mi.) to the Echo Lake Substation, located north of the Kangley area and southwest of North Bend (Figure 1).

1.1.1 Construction Methods

BPA would construct all of the action alternatives using the existing practices described below for building transmission lines and substations. BPA would build or improve access roads as necessary. If additional easements for right-of-way (ROW) or access roads were needed, additional rights would be obtained from landowners. BPA typically uses existing, cleared staging areas in which to store and assemble materials or structures.

After the structures are in place and conductors are strung between the structures, BPA would restore disturbed areas.

The following sections describe in greater detail the sequential steps that BPA typically takes to construct a transmission line.

1.1.1.1 Right-of-Way Requirements

BPA would obtain easements from landowners for the new transmission line ROW, and easements for the access roads outside of the transmission line ROW easements. The easements give BPA the right to construct, operate, and maintain the line and access roads. A 150-foot (ft.) ROW width is assumed for the 500-kV line.

Fee title to the land comprising the easement generally remains with the owner, subject to the provisions of the easement. The easement prohibits large structures, tall trees, storing of flammable materials, and other activities that could be hazardous to people or could endanger the transmission line. Activities that do not interfere with the transmission line or endanger people are usually not restricted.

Rights (usually easements) for new access roads would be acquired from property owners, as necessary. A 50-ft. ROW easement generally would be acquired for new access roads measuring about 16 ft. wide, and 20 ft. of ROW would be required for any existing access roads.

1.1.1.2 Clearing

The height of vegetation within the ROW would be restricted to provide safe and reliable operation of the line. Trees would be cleared within the ROW as well as outside of the ROW to prevent trees from falling onto the lines. A clearing advisory would be generated using ground information from cross section data. This clearing advisory would specify a safe vegetation height along and at varying distances from the line. The amount of vegetation removed would be based on this clearing advisory and local knowledge of regional conditions such as weather patterns, storm frequency and severity, general tree health, and soils. Other factors that influence the amount of clearing along the line are the line voltage; vegetation species, height, and growth rates; ground slope; conductor elevation above the ground; and clearance distance required between the conductors and other objects.

Merchantable timber purchased from private owners would be marketed and non-merchantable timber would be left lopped and scattered, piled, chipped, or would be taken off-site. Contractors would be required to use equipment that leaves low-growing vegetation in place instead of dirt blades on bulldozers for clearing. Other specialized brushing/mulching equipment may also be required. Additional best management practices (BMPs) for timberland would also be used.

At the tower sites, all trees, brush, and snags would be felled. Stumps would be removed at these sites only if they interfere with tower and guy installation. The site would be graded to provide a relatively level work surface. The total amount of clearing required for this project is unknown at this time.

An additional amount of land would be cleared for roads that are needed off the ROW and for roads determined to be in poor condition and requiring upgrading by BPA.

1.1.1.3 Access Road Construction and Improvement

An access road system within and outside of the ROW would be used to construct and maintain a new line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. Roads generally would be surfaced with gravel, and appropriately designed for drainage and erosion control. The access roads would generally have grades of 6% or less for erodible soils and 10% or less for resistant soils. The maximum grades would be 15% for trunk roads and 18% for spur roads. No permanent access road construction would be allowed in cultivated or fallow fields.

Clearing and construction activities for new access roads would disturb an area about 20 ft. wide, depending on terrain. New roads would be constructed within the ROW wherever possible, but where conditions dictate otherwise, roads would be constructed and used outside of the ROW. Construction of new roads is recommended only to access new towers to avoid greater wetland or stream impacts. In several places, new access roads would be constructed in uplands within the new transmission line corridor to avoid wetlands that occur within the existing alignment.

Dips, culverts, and waterbars would be installed within the roadbed to provide drainage. Fences, gates, cattle guards, and additional rock would be added to access roads as necessary.

Where temporary roads are used, any disturbed ground would be repaired and, where land use permits, the road would be reseeded with grass or other appropriate seed mixtures. After construction, access roads would be used for line maintenance. Where ground must be disturbed for maintenance activities, the roadbed would be repaired and reseeded as necessary.

The amount of new roads required for this project would vary depending on the alternative chosen and the feasibility of using existing roads along the line.

1.1.1.4 Storage, Assembly, and Refueling Areas

Construction contractors usually establish storage areas near the transmission line where they can stockpile materials for structures, spools of conductor, and other construction materials. These areas would be accessible from major highways. Structural steel would be delivered in pieces on flatbed trucks and would be assembled on-site. A mobile crane may be needed to handle the bundles. If the terrain were too steep at the actual tower site, general assembly yards would be used to erect the tower in pieces. The structure would then be transported to the tower site by truck or helicopter. Because trucks and helicopters need to refuel often, these construction areas could also be used for refueling.

1.1.1.5 Tower Site Preparation

Site preparation begins with removing all vegetation from a tower site. In areas of uneven topography, the site would be graded to provide a level work area. An average area of 30,000 square feet (150 by 200 ft.) would be disturbed at each tower site. Additional areas that could be disturbed include the site where the conductor is strung and pulled. These disturbances could be as large as a 370-ft. radius from the tower center.

Bulldozers would be used to clear and construct any new access roads to the transmission line towers and any new tower site landings. Manual methods, including chainsaws and brush hogs, would be used to clear the new ROW. BMPs would be used during clearing and construction to reduce impacts.

In addition to clearing the ROW for the transmission line towers, construction crews would remove selected trees outside of the ROW. This additional clearing would be done to reduce the possibility of blowdown. Blowdown occurs when newly exposed trees fall after the initial clearing process because they have not developed the root structure to remain standing once they become more fully exposed to strong winds.

1.1.1.6 Towers and Tower Construction

Steel lattice towers would be erected to support the transmission line conductors. The new towers would be similar in design to those used in the existing Schultz-Raver No. 2 500-kV transmission line. The height of each tower would vary by location and surrounding land forms. Towers would average 135 ft. high and would be spaced about 1,100 to 1,200 ft. apart. Under Alternatives 1 and 2 (described in the next section), where the new line would parallel a portion of the existing Raver-Echo Lake transmission line, towers would be staggered so that a tower from one line would not contact a tower from the other line in the unlikely event that a tower falls.

Most towers used on the proposed line would be “tangent” or “suspension” towers. This type of tower is designed to support conductors strung along a virtually straight line with only small turns or angles. “Deadend” towers would also be used on a limited basis where stresses on the transmission line conductors would have to be equalized because of changes in direction, because of the need to support an excessively long span, or where a span crossing is needed for extremely steep or rugged terrain or a river. Deadend towers use more insulators and heavier steel than tangent or suspension towers, thus making them more visible. Deadend towers also are more costly to build than suspension towers.

The towers would usually be constructed from the ground, rather than using helicopters. The equipment used depends on the weight and size of the towers and such site conditions as weather and soil characteristics. Most 500-kV lines would be built using mobile cranes; helicopter tower erection could be used if access was not available or if sensitive resources would be encountered.

Steel towers would be assembled in sections near the tower site. Each tower contains three components: the legs, body, and bridge. The bridge is the uppermost portion of the tower and serves as the attachment point for the insulators that support the conductors.

Steel towers are anchored to the ground by footings. Each tower requires four footings placed in holes that have been excavated, augered, or blasted. Large machinery, such as backhoes or truck-mounted augers, would be used to excavate the footings. Topsoil would be stockpiled during excavation. The design of the footings would vary based upon soil properties, bedrock depth, and the soundness of the bedrock at each site. Typically, towers would be attached to steel plates or grillages placed within the excavated area. The areas would then be backfilled with excavated material or concrete. Topsoil would then be replaced to restore the original ground surface.

Typical footings for single-circuit towers include 4- by 4-ft. plates placed 10 to 12 ft. deep for suspension towers and 12.5- by 12.5-ft. grillage placed 14 to 16 ft. deep for heavy dead-end towers. On average, for an entire transmission line project, each footing would occupy an area about 10 by 10 ft. to a depth of 15 ft. if bedrock was not encountered. The holes in which the plates and grillage would be installed must be large enough to provide about 1 ft. of clearance on each side of the plate or grillage. If bedrock were encountered and had properties that allowed anchor borings, holes would be drilled and steel rods grouted into the rock. These rods would either be attached to a concrete footing or welded directly to a tower member and embedded in compacted backfill. If rock properties were not suitable for anchor rods, the rock may be blasted to obtain adequate footing depth.

As the towers were built, heavy machinery would disturb the ground surface and/or compact soils at the tower site and along access roads. Noise and dust also would be generated by the machinery.

1.1.1.7 Conductors, Overhead Ground Wires, and Insulators

The wires or lines that carry the electrical current in a transmission line are called conductors. Alternating-current transmission lines such as the proposed line require three wires or sets of wires, each of which is referred to as a "phase." Three 1.3-in. Bunting conductors would be included for each phase. Each bundle is 16 by 20 in.

Conductors are not covered with insulating material. Instead, air is used for insulation. Conductors are physically separated by insulators on transmission towers.

After the transmission towers are in place, workers would attach a smaller steel cable to the towers and then pull the conductor under tension through the towers. Conductors would be attached to the structure using glass, porcelain, or fiberglass insulators. Insulators prevent the electricity in the conductors from moving to other conductors on the tower, the tower itself, and the ground. As the conductors are strung, the ground surface would be disturbed at the tensioning sites, and noise and dust would be generated by the machinery.

Transmission towers elevate conductors to provide safe clearance for people and structures within the ROW. The National Electrical Safety Code (NESC) establishes minimum conductor heights. The minimum conductor-to-ground clearance for a 500-kV line is a little more than 29 ft. Greater clearances would be provided by BPA over county roads and highways, railroads, and river crossings.

One or two smaller wires, called overhead ground wires, would also be attached to the top of the transmission towers. Overhead ground wires would protect the transmission line against lightning damage. The diameter of the wire would vary from 0.375 to 0.625 in.

1.1.1.8 Substation Additions

Under the current proposal, the Echo Lake Substation would be expanded to the east on land owned in fee title by BPA. The size of the expansion would be 300 by 750 ft. The site would be cleared in the same manner as the ROW for the transmission line. The site would include a fenced yard and a graded and graveled parking lot. The existing road around the substation would be realigned to the east to accommodate this expansion. New transformers, switches, and other equipment would be installed in the expanded area. A continuous ground wire would also be installed.

1.1.1.9 Site Restoration and Clean-up

Disturbed areas around the towers, conductor reels, and pull site locations would be reshaped and contoured to be consistent with their original condition. Access roads would be repaired.

Disturbed areas would be reseeded with grass or an appropriate seed mixture to prevent erosion. The seed mixture would include native plant species and would be free of noxious weeds. All solid waste from construction would be removed and properly disposed offsite, and equipment would be removed from the ROW.

1.1.2 Alternative Rights-of-Way

A portion of the action alternatives would be located within the Cedar River Municipal Watershed. The alternatives would begin at the Schultz-Raver No. 2 500-kV transmission line and generally travel northward to the Echo Lake Substation. (See Figure 2.) Under all alternatives, the transmission line ROW would be 150 ft. wide. Miles of new access roads were calculated for a 20-ft. ROW within a 0.25-mile buffer on each transmission line alternative.

1.1.2.1 Alternative 1: Preferred Alternative

The alignment for Alternative 1 would be immediately adjacent and parallel to a portion of the existing 12-mi. Raver-Echo Lake transmission line from a point approximately 3 mi. north of Raver (S26, T22N, R7E) to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 0.8 mi. of new access roads. The existing 150-ft. ROW would be widened to 300 ft., with the widening and new line located east of the existing corridor.

1.1.2.2 Alternative 2

Alternative 2 would originate from tap point #2 (Figure 2) located approximately 2 mi. east of the tap point #1 for Alternative 1 (S25, T22N, R7E). The line would traverse approximately 3 mi. to

S11, T22N, R7E before continuing north along the same alignment as Alternative 1, paralleling the existing Raver-Echo Lake transmission line, and terminating at the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 2.8 mi. of new access roads.

1.1.2.3 Alternative 3

Alternative 3 would begin at the tap point #2 (S25, T22N, R7E); traverse northeast to S8, T22N, R8E; and then turn north-northwesterly to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 10.2 mi. long and would require about 6.4 mi. of new access roads.

1.1.2.4 Alternative 4a

Alternative 4a would begin about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverse northwest to connect with Alternative 1 over 1 mi. (S23, T22N, R7E) further south from where Alternative 2 reconnects (S11, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.5 Alternative 4b

Alternative 4b would begin slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverse west to connect with Alternative 1 further south from where Alternative 4a reconnects (S23, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.6 No Action Alternative

Under the No Action Alternative, a new 500-kV electrical transmission line would not be built. As a result, transmission line capacity could be reached or exceeded as early as 2002-2003 if a cold winter were to occur in the Seattle metropolitan area and the existing Raver-Echo Lake transmission line were to go out of service. Relying upon the existing transmission system during periods of increased demand and compromised reliability could result in brownouts or rolling blackouts in the area. Thus, residents, businesses, and government agencies could experience as much as several days without electricity. Loss of electricity for lights and heating could halt business and government activities. Residents would have to rely upon other energy sources for heating, cooking, and lighting, such as wood and gas fireplaces, stoves and barbecues, oil lamps and candles, etc.

1.2 Key Issues for Wetlands

Wetlands are susceptible to degradation from excavation, fill, and clearing. Federal, state, and local agencies require the disclosure of potential impacts to wetlands associated with the construction and maintenance of the transmission line.

The majority of wetlands that would be affected are associated with forested habitats that would be permanently altered, by removal of trees and construction of access roads, with construction of the transmission line. Moderate to high levels of impact to wetlands would occur with the construction of any of the proposed transmission line alternatives.

Impacted wetland functions associated with vegetation clearing and access road construction are wildlife habitat, water quality improvement, flood storage, moderation of flood flow, and groundwater discharge and recharge. In forested wetlands, permanent impacts would occur where herbaceous vegetation and trees are removed. These wetlands would be permanently maintained as scrub-shrub or emergent wetlands. Minimizing the disturbance to soil structure during clearing would reduce impacts to water quality, flood storage, and flood flow moderation functions.

Where possible, BPA would place new roads and tower structures outside of wetland areas to avoid permanently altering wetland hydrology and soils through excavation or fill.

1.3 Major Conclusions

A total of 23 wetlands were identified within the project area during the October 2000 site reconnaissance. An additional 31 wetlands were identified during the reconnaissance of the preferred Alternative 1 in April 2001. Alternative 3 would result in the least impact to wetlands with a total of 6 acres (ac.) of clearing impacts. Impacts to wetlands associated with the construction of the transmission line would be limited to the clearing of vegetation and construction of access roads. Operation and maintenance impacts would be similar except with less severity. Potential fill and excavation impacts from the construction of towers would be avoided by strategically locating towers outside of wetland areas and by spanning wetlands.

The majority of wetlands within the proposed ROWs are forested. Permanent impacts to wetland functions would occur from the removal of trees and the maintenance of shrub communities within the 150-ft. transmission line ROW. Key wetland functions that would be degraded from construction of the transmission line are wildlife habitat, flood storage and flood flow moderation, and water quality. Identifying and avoiding wetland resources before and during construction, and limiting disturbance to the minimum necessary when working in and immediately adjacent to wetlands, would minimize wetland impacts. New road construction could carry sediment into wetlands, affecting water quality and biological productivity; however, use of erosion control devices would minimize these indirect impacts.

2.0 Study Scope and Methodology

2.1 Data Sources and Study Methods

The collection of wetland data for the project area focused on two tasks:

- Habitat-Based Evaluation
- Field Verification

The habitat-based evaluation was initiated by reviewing existing data and literature applicable to the project area. Background review of wetlands data for the project area was based on:

- U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps (USDI 1987 map series).
- Wetland maps and other information from the Cedar River Watershed (CRW) Habitat Conservation Plan (HCP) (City of Seattle 2000).

- 1:24,000-scale orthophotos.
- U.S. Geological Survey (USGS) 7.5-minute series quadrangle topographic maps.

A basemap of potential wetland locations was created by superimposing the transmission alternatives over the wetlands location data provided by the aforementioned data sources. This map was used to aid the field survey of wetlands within the ROWs. The wetlands reconnaissance conducted in October 2000 focused on field-verifying selected areas of the wetland basemap that may be impacted. The approximate wetland boundaries were then field-mapped on the orthophotos provided by BPA.

Jones & Stokes wetland biologists located wetlands within a 500-ft. survey corridor during the week of October 23 to 27, 2000. Wetlands previously identified by King County were located. In addition, several other wetlands not identified by King County or other sources were located. A global positioning system was used to field-verify the location of each wetland. No waters of the United States were "delineated"; subsequently no jurisdictional wetland boundaries were established for the purposes of the Draft Environmental Impact Statement. Wetland biologists located wetlands, including waters of the United States, using criteria for jurisdictional wetland identification developed by the U.S. Army Corps of Engineers (Environmental Laboratory 1987), the Washington State Department of Ecology (Ecology 1997). Wetland class, rating, and size were determined at each wetland location. Wetlands were classified following the standardized national system established in Cowardin et al. (1979). Wetlands were rated and buffer widths were assigned based on the King County Environmentally Sensitive Areas Ordinance (King County Code 21A.24.320). Due to the size of the wetlands and their readily apparent signature on the aerial photographs, the boundaries were sketched on 1:24,000-scale aerial photographs and subsequently digitized electronically to the aerial orthophotos using the ArcView mapping program.

Wetlands within the 500-ft. corridor were mapped by alternative consecutively from south to north. Wetlands were numbered based upon their association with a primary alternative and the order from south to north. For example, the southernmost wetland located on Alternative 2 is wetland 2-1. Alternatives 1, 2, 4a, and 4b share portions of the same ROWs; thus, some wetlands are common to several alternatives.

In April 2001, a reconnaissance of wetlands and streams within the preferred Alternative 1 was conducted to map the locations of jurisdictional waters of the United States. The purpose of this reconnaissance was to provide BPA tower and road engineers flagged locations of jurisdictional waters in the field to better site access roads and towers to avoid impacts to the resources. Wetland biologists walked the entire 150-ft wide ROW of the preferred Alternative 1 and flagged the boundaries of waters of the United States, using criteria for jurisdictional wetland identification developed by the U.S. Army Corps of Engineers (Environmental Laboratory 1987), the Washington State Department of Ecology (Ecology 1997). Within each wetland encountered vegetation, hydrology, and soils data was recorded. Approximate wetland boundaries were sketched on the 1:24,000-scale orthophotos provided by BPA. Wetlands within the 150-foot Alternative 1 corridor were labeled according to the proposed transmission line tower moving south to north. For example, the southernmost wetland located on Alternative 1 is wetland 78/5-1. Thus, this wetland is the first wetland north of proposed tower 78/5.

Wetland impacts were calculated for Alternatives 2, 3, 4a, and 4b using the ArcView mapping program by overlaying each 150-ft. ROW on the October 2000 surveyed wetlands. The sum of potential wetland impacts from vegetation clearing was then calculated for each alternative. In

September 2001, BPA provided a map of proposed towers and access roads locations associated with the preferred Alternative 1. This map was used to calculate potential impacts to the April 2001 reconnaissance wetlands, from the vegetation clearing for the 150-foot wide proposed transmission line corridor to wetlands associated with Alternative 1. As the access road network was developed, further field reconnaissances conducted during summer 2001 resulted in hand-measured approximate impacts to wetlands from the proposed access road construction (e.g., new roads, road upgrade, culvert installation). See Section 4.0 for potential impacts on wetlands.

2.2 Agencies Contacted

Agencies contacted include the U.S. Army Corps of Engineers (Corps) and the City of Seattle.

3.0 Affected Environment

3.1 Regional Overview

The project area is located within the Cascade foothills of western Washington, between the City of North Bend and the Kangley area. A major portion of each proposed ROW passes through the CRW and private timberlands. Within the area, primary land holders, including "in fee" ROWs and easements, include BPA, Weyerhaeuser Timber Company, Washington Department of Natural Resources (WDNR), City of Seattle, and private residential landowners.

Water Resource Inventory Areas (WRIAs) designated by the Washington Department of Ecology that are crossed by the proposed ROWs include Lake Washington (#8), Snohomish River (#7), and Green River (#9).

Wetlands within the region are typical of the Puget Lowland and western Cascade Mountain foothills. Wetland soils are often formed in porous gravels, sands, and clay and silt tills derived from glacial deposits. Mixed deciduous and coniferous-forested wetlands with pockets of shrub, emergent, and open water communities are common. Wetland water sources include hillside seeps, perched water tables, overland runoff, precipitation, and flows from adjacent streams.

3.2 Regulations, Standards, and Guidelines

3.2.1 Federal

The Clean Water Act (CWA) Section 404 requires the avoidance of development in wetlands wherever practicable. Wetlands are important natural communities that deserve special consideration because of historical and current regional and statewide losses, and because of the federal laws and policies that pertain to their protection. Wetland communities in the project ROWs play a vital role in groundwater discharge, supporting stream baseflow, capturing sediment and nutrient runoff, and providing habitat for wildlife and plant species.

Under Section 404 of the CWA, the Corps and the U.S. Environmental Protection Agency (EPA) regulate the placement of dredge and fill material into waters of the United States, which include jurisdictional wetlands. Although the CWA protects wetlands, filling of wetlands can occur after a Section 404 permit is issued by the Corps.

For regulatory purposes, the federal agencies define wetlands as follows:

> Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (CFR 328.3, CFR 230.3).

Other waters of the United States include seasonal or perennial surface water features, such as streams and drainages, that are not considered wetlands because they do not meet one or more of the three mandatory technical criteria that characterize jurisdictional wetlands (i.e., hydrophytic vegetation, hydric soil, and wetland hydrology), as defined by the Corps Wetlands Delineation Manual (1987). Please see the Fisheries Technical Report for a complete discussion of these other surface water features within the project area.

3.2.2 State

Section 401 of the federal CWA requires that proposed dredge and fill activities permitted under Section 404 be reviewed by the Washington Department of Ecology (Ecology) for compliance with state water quality standards. Certification ensures that federally permitted activities comply with the federal CWA, state water quality laws, and any other state aquatic protection requirements (unless certified by the state, the federal Section 404 permit is considered invalid).

3.2.3 Local

Compliance with King County Sensitive Areas Ordinance (Ordinance #9614) is required whenever proposing a project located near or in critical areas wetlands. Wetlands within the project ROWs were rated using the criteria defined in the King County Sensitive Areas Ordinance. This ordinance categorizes wetlands into Class 1, 2, and 3 based on the size, the presence of species listed as threatened or endangered, and the number of vegetation classes present.

The King County Sensitive Areas Ordinance requires minimum buffer widths for wetlands, as determined by the wetland category. Wetland buffers are measured from the wetland edge. The King County Sensitive Areas Ordinance provides for permanent protection of wetlands and their buffers by regulation of development and other activities. Minimum buffer requirements are:

- Class 1: 100 ft.
- Class 2: 50 ft.
- Class 3: 25 ft.

In addition, and unless otherwise specified, a minimum building setback of 15 ft. is required from the edge of a wetland buffer.

3.3 Study Area

The study area for wetlands included a 500-ft. wide corridor along all of the transmission line alternatives. The primary focus of the wetlands analysis was on identifying wetlands within the proposed 150-ft. ROW centerline of each transmission line corridor. The wetlands within the 150-ft. ROW were judged most vulnerable to impacts resulting from construction and maintenance of the transmission lines, because the ROW would be cleared of vegetation and would include access roads and transmission line towers. Figure 3 presents the location of all wetlands surveyed within the ROWs during the October 2000 reconnaissance. Table 1 presents the wetland identification numbers and vegetation classes by alternative as surveyed in October 2000.

Table 1. Summary of Wetlands Present within 150-ft. ROW by Transmission Line Alternative

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 500-foot Study Corridor	WRIA
Alternative 1				
1-1	PFO	Class 2	9	#8 – Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	POW/PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO	Class 1	8	#7 - Snohomish River
Total			242	
Alternative 2				
2-1	PSS/PFO	Class 2	1	#8 - Lake Washington
2-2	PFO	Class 2	3	#8 - Lake Washington
2-3	PFO	Class 2	15	#9 - Green River
1-1	PFO	Class 2	9	#8 – Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	POW/PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO	Class 2	8	#7 - Snohomish River
Total			261	

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 500-foot Study Corridor	WRIA
Alternative 3				
3-1	PFO/PSS	Class 2	22	#8 - Lake Washington
3-2	PFO/POW	Class 2	6	#8 - Lake Washington
3-3	PFO	Class 2	10	#9 - Green River
3-4	PFO	Class 2	12	#8 - Lake Washington
3-5	PFO	Class 2	10	#8 - Lake Washington
3-6	PFO/PSS	Class 2	2	#7 - Snohomish River
3-7	PFO/POW	Class 2	6	#7 - Snohomish River
3-8	PFO	Class 2	6	#7 - Snohomish River
3-9	PSS	Class 3	1	#7 - Snohomish River
Total			75	
Alternative 4a				
2-1	PSS/PFO	Class 2	1	#8 - Lake Washington
2-3	PFO	Class 2	15	#9 - Green River
1-1	PFO	Class 2	9	#8 - Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO/POW	Class 1	8	#7 - Snohomish River
Total			258	
Alternative 4b				
2-1	PSS/PFO	Class 2	1	#8 - Lake Washington
2-2	PFO	Class 2	3	#8 - Lake Washington
2-3	PFO	Class 2	15	#9 - Green River
1-1	PFO	Class 2	9	#8 - Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 500-foot Study Corridor	WRIA
1-7	POW/PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO	Class 2	8	#7 - Snohomish River
Total			261	
Substation				
Echo 1	PEM/PSS	Class 2	7	#7 - Snohomish River

*Vegetation class definitions (as defined by Cowardin et al. 1979, Classification of Wetlands and Deepwater Habitats. U.S. Fish and Wildlife Service):
PEM – Palustrine Emergent
PFO – Palustrine Forested
PSS – Palustrine Scrub-Shrub
POW – Palustrine Open Water

** King County ratings are explained in Appendix B.

A total of 23 wetlands were identified within the ROWs during the October 2000 reconnaissance for wetlands. Additional wetlands were identified during the reconnaissance of the 150-foot-wide preferred Alternative 1 in April 2001. Figure 3 illustrates the relationship between wetlands identified during the October 2000 field reconnaissance and the 500-ft. transmission line ROW. Figure 4 details the wetlands identified during the April 2001 reconnaissance of the preferred Alternative 1 within the proposed 150-ft transmission line ROW. Discrepancies between the size and shape of wetlands presented in Figures 3 and 4 are attributed to survey methods. Wetlands boundaries surveyed in April 2001 reflect the detail necessary to site access roads and towers to avoid and minimize impacts to waters of the United States, including wetlands within the preferred Alternative 1 ROW. Thus, additional wetlands were inventoried and boundaries of wetlands presented in 4 were adjusted (see Figure 4).

Wetland vegetation classes in the proposed ROWs included palustrine emergent, scrub-shrub, open water, and forested wetlands as defined by Cowardin et al. (1979). Commonly wetlands on flat bench areas were associated with depressional areas that receive water from overland runoff and precipitation. Wetlands on the north and south side of Brew Hill (Alternative 1) and wetlands generally located on slopes were fed by groundwater discharge seeps. Most wetlands were generally greater than 1 ac. in size and included a mosaic of wetland and upland areas following small variations in topography. Several wetlands were also found to be associated with the riparian strips of streams.

The majority of wetlands within the CRW have been protected from recent timber harvest and have intact mixed conifer and deciduous forested components. However, the existing roads system does cross wetlands in places, thereby reducing vegetation cover and altering surface and subsurface flows within these wetlands. The majority of wetlands located north of the CRW have been impacted by timber harvest and are currently dominated by deciduous trees and shrubs, or sapling conifers rather than the mixed deciduous/coniferous tree dominated wetlands common to the CRW. Common dominant wetland plant species included red alder, western hemlock, western red cedar, salmonberry, Douglas’ spirea, skunk cabbage, piggy-back plant, and slough sedge. (Please see Appendix A for scientific names of dominant plant species surveyed within the project area.)

Wetland buffers within the 150-ft ROW of each of the alternatives were generally intact and forested within the CRW. Wetland buffers extending within the cleared existing alignment associated with Alternative 1 have been cut to allow conductor span, and generally maintain low shrub and herbaceous cover. Wetland buffers within the private timberlands to the north of the watershed reflect the mosaic past and recent timber harvest, and are generally intact and dominated by a mix of shrubs, and young deciduous and coniferous trees.

The wetlands in the ROWs provide many functions and values that directly or indirectly benefit society. Many of the depressional and seep discharge wetlands in the ROWs are forested, located within the upper third of their respective watershed, and connected to drainages, all of which are factors that increase the flood storage and flood flow moderation wetland functions. Several wetlands are associated with the riparian fringe of streams, a factor that plays an important role in filtering pollutants and sediments before they reach the waterway. High vegetative structural complexity within the wetlands and adjacent intact forested upland communities may provide foraging, breeding, cover, and rearing habitat for many wildlife species.

Wetland buffers provide important functions, including protection of wetland functions and values, water quality improvement, wildlife habitat, and deterrence of human access and associated impacts. Vegetated buffers may reduce impacts to water quality in wetlands by controlling soil erosion and filtering out pollutants. Vegetated buffers provide essential life needs for birds and mammals that are considered to be dependent on wetlands.

3.4 Transmission Line Alternatives

3.4.1 Alternative 1: Preferred Alternative

A total of 10 wetlands, totaling 242 ac., were identified within the 500-ft. transmission line study corridor for Alternative 1 during the October 2000 reconnaissance (see Table 1). All of the wetlands identified within the 500-ft. corridor would be crossed by the proposed 150-ft. ROW centerline. The December 2001delineation of the 150-ft. preferred Alternative 1 corridor identified 30 wetlands totaling 15.1 acres. Table 2 lists the 30 wetlands surveyed during the December 2001 delineation (please refer to Figure 4 for wetland locations within Alternative 1). The discrepancy between the two surveys is attributable to the survey methods described in Chapter 2.1.

Table 2. Alternative 1 Wetlands Surveyed During the December 2001 Reconnaissance of the 150-Ft.-Wide Corridor

Wetland ID[a]	Vegetation Class[b]	King Co. Rating[c]	Total Acres Within 150-Foot Study Corridor	WRIA
78/5-1	PFO/PSS	2	0.3	#8 – Lake Washington
78/5-3	PFO	2	0.9	#8 – Lake Washington
79/1-1	PFO/PEM	2	0.4	#8 – Lake Washington
79/2-1	PFO/PSS/PEM	2	0.4	#8 – Lake Washington
79/3-1	PFO/PSS/PEM	2	0.3	#8 – Lake Washington

Wetland ID[a]	Vegetation Class[b]	King Co. Rating[c]	Total Acres Within 150-Foot Study Corridor	WRIA
79/3-2	PFO	3	<0.0	#8 – Lake Washington
79/4-2	PFO	2	<0.0	#8 – Lake Washington
79/5-1	PFO/PSS	2	2.2	#8 – Lake Washington
80/1-1	PFO/PSS	2	0.8	#8 – Lake Washington
80/2-1	PFO/PSS	2	0.1	#8 – Lake Washington
80/2-2	PFO/PSS	2	1.1	#8 – Lake Washington
80/3-4	PFO/PEM	3	<0.0	#8 – Lake Washington
80/5-1	PFO	3	0.1	#8 – Lake Washington
81/1-1	PFO	3	0.1	#8 – Lake Washington
81/4-1	PFO/PSS	2	0.9	#7 - Snohomish River
81/5-1	PFO/PSS	2	0.5	#7 - Snohomish River
81/6-1	PSS	2	0.2	#7 - Snohomish River
81/7-1	PFO/PSS	3	0.3	#7 - Snohomish River
82/4-1	PFO	2	0.5	#7 - Snohomish River
82/4-2	PFO	3	0.1	#7 - Snohomish River
82/4-3	PSS	3	<0.0	#7 - Snohomish River
82/5-2	PFO/PSS	2	0.8	#7 - Snohomish River
83/1-1	PFO/PSS	2	0.9	#7 - Snohomish River
83/1-2	PFO/PSS	2	0.5	#7 - Snohomish River
83/3-1	PFO/PSS	2	1.3	#7 - Snohomish River
83/4-1	PFO/PSS	2	0.2	#7 - Snohomish River
83/6-1	PFO/PSS	2	0.7	#7 - Snohomish River
83/6-3	PSS/PFO	3	0.2	#7 - Snohomish River
84/1-1	PSS	3	0.7	#7 - Snohomish River
84/4-4	PEM/PSS	2	0.6	#7 - Snohomish River
Total			15.1	

[a] Additional wetlands were surveyed outside of the 150-ft.-wide corridor that are not listed here.

[b] Vegetation class definitions (as defined by Cowardin et al. 1979, Classification of Wetlands and Deepwater Habitats. U.S. Fish and Wildlife Service):
PEM – Palustrine Emergent
PFO – Palustrine Forested
PSS – Palustrine Scrub-Shrub
POW – Palustrine Open-Water

[c] King County ratings are explained in Appendix B.

Large depressional wetlands occupy flat benches on the north and south slopes of Brew Hill and are often fed by groundwater seeps. Several wetlands are also associated with the riparian area of tributaries to the Raging River to the north and Rock Creek to the south of Brew Hill, within the watershed and within private lands. Many of the wetlands continue outside of the 150-ft corridor into the existing transmission line corridor and onto adjacent lands.

A majority of wetlands in this alternative have a palustrine forested vegetation community component dominated by red alder. The red alder forest is often associated with western red cedar and western hemlock in the canopy. Salmonberry, and Douglas' spirea are common wetland shrub species, with piggy-back plant, meadow buttercup, and skunk cabbage often dominating the herbaceous layer. The depressional wetlands occupying the south and north bench areas of Brew Hill provide important groundwater discharge and recharge functions, while serving as the headwaters for Rock Creek and the Raging River. These forested wetland communities also provide bird, mammal, fish, amphibian, and invertebrate habitat for a variety of species that use seasonally and perennially saturated wetlands and riparian areas for feeding, nesting, and rearing.

No wetlands were identified south of the Cedar River crossing within the Alternative 1 ROW.

3.4.2 Alternative 2

A total of 13 wetlands, totaling 261 ac., were identified within the 500-ft. study corridor for Alternative 2. Three wetlands were identified south of the junction with Alternative 1. North of this junction (which is within Alternative 1), within the CRW, there are 10 wetlands (described under Alternative 1 above).

All three of the wetlands identified within the southern portion of this alternative are located south of the Cedar River, and all three wetlands are within the proposed 150-ft. ROW. All are depressional wetlands with palustrine forested vegetation community components and areas of surface water inundation. Two of these wetlands have been altered. Tree harvesting has impacted the buffer associated with wetland 2-1, while the location of Pole Line Road has altered the hydrology of wetland 2-2. Wetland 2-3 is located within mid-seral coniferous forest and, like the other two wetlands, is associated with a depressional area within relatively flat topography.

3.4.3 Alternative 3

A total of nine wetlands, totaling 75 ac., were identified within the 500-ft. study corridor along Alternative 3. Wetlands are located to the north and south of the CRW, as well as within the watershed. Seven of nine wetlands identified within the study corridor would be crossed by the proposed 150-ft. ROW.

Most of the wetlands are associated with depressions that collect overland flows and precipitation and hold this water over prolonged periods. These wetlands provide water quality, flood storage, and flood water retention functions. Vegetation communities are predominantly palustrine forested with components of palustrine scrub-shrub with low diversity. Wetlands 3-8 and 3-4 contain open water surrounded by red alder-dominated, palustrine forested wetland.

Several wetlands are associated with the riparian fringe of streams that provide wildlife habitat and wildlife travel corridors, as well as water quality improvement, flood storage, and floodwater retention. Wetland 3-9 is a palustrine forested wetland paralleling the north and south sides of Canyon Creek. Wetland 3-5 fringes an unnamed tributary to Raging River. Wetland 3-4 contains a large open water component forming the headwaters to Steele Creek, a tributary to the Cedar River.

3.4.4 Alternative 4a

A total of 12 wetlands, totaling 258 ac., were identified along the entire length of the Alternative 4a 500-ft. study corridor. Wetland 2-3 was identified along the portion of Alternative 4a that begins about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverses northwest to connect with Alternative 1, over 1 mi. (S23, T22N, R7E) further south than where Alternative 2 reconnects (S11, T22N, R7E).

Ten of the 12 wetlands identified within the Alternative 4a 500-ft. study corridor were previously described in Section 3.4.1 for Alternative 1. The remaining two wetlands (2-1 and 2-3) are described in Section 3.4.2 for Alternative 2. However, wetland 2-3 is not within the proposed 150-ft. ROW and would not be directly impacted.

3.4.5 Alternative 4b

A total of 13 wetlands, totaling 261 ac., were identified along the entire length of Alternative 4b. Wetlands 2-2 and 2-3 were identified along the portion of Alternative 4b that begins slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverses west to connect with Alternative 1 further south than where Alternative 4a reconnects (S23, T22N, R7E).

Ten of the 13 wetlands identified within Alternative 4a were previously described in Section 3.4.1 for Alternative 1. The remaining wetlands are described in Section 3.4.2 for Alternative 2. However, wetland 2-3 is not within the proposed 150-ft. ROW and would not be directly impacted.

3.5 Access Roads

An access road system within and outside of the ROW would be used to construct and maintain the new transmission line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. New and improved roads generally would be surfaced with gravel, with appropriate design for drainage and erosion control.

Access roads would be located to avoid the identified wetlands where possible.

3.6 Substation

One wetland of about 7 ac. size is located within the footprint of the Echo Lake Substation expansion. Wetland E-1 is located at the base of the hillslope within a depressional area to the east and south of the current Echo Lake Substation. The wetland is a mixture of palustrine scrub-shrub and palustrine emergent vegetation communities. Water emerges within the proposed expansion area as a seep, draining over the surface to the west of the proposed substation expansion area into the existing Raver-Echo Lake transmission line ROW.

4.0 Environmental Consequences

For all transmission line alternatives, impacts to wetlands would occur during construction and operation (maintenance). Impacts to wetlands could occur during construction of new roads or widening of existing access roads, clearing vegetation within the 150-ft. wide ROW, preparation and clearing vegetation for staging and materials storage areas, clearing vegetation for work areas, and clearing and grubbing for construction of tower footings. Operational impacts to wetlands could include the periodic removal of vegetation within or adjacent to wetlands to ensure proper clearance to conductors.

A **high impact** to wetlands would occur if the project:

- Permanently altered wetland hydrology, vegetation, and/or soils by excavation or fill, and the ecological integrity of a wetland was impaired; or
- Completely filled a wetland or destroyed a wetland function.

A moderate impact would occur if the project:

- Partially filled a wetland or degraded a wetland function. Recovery generally would require restoration and monitoring.

A **low impact** would occur if the project:

- Changed vegetation or soils for the short term but did not change hydrology; or
- Caused a short-term disruption of a wetland function.

No impact would occur if the project avoids wetlands and their buffers; if new or widened access roads do not affect wetlands and buffers; if construction, operation, and maintenance of facilities does not affect wetlands and buffers; or if the size, quality, and functions of existing wetlands are not reduced.

4.1 Construction Impacts

4.1.1 Impacts Common to All Action Alternatives

4.1.1.1 Impacts

Each transmission line ROW would cross stream channels, valleys, and other landforms supporting wetlands. The conductor would span wetlands, and new structures and roads would be sited to avoid wetlands wherever possible. A 150-ft. wide ROW generally would be cleared of all trees, except when crossing steep, deep drainages or in other locations where conductor clearance was sufficient.

Direct construction impacts within wetlands would occur from hand-clearing the ROW for conductor span, and from permanent fill resulting from access road construction. No towers would be placed in wetland areas. Although clearing of forested wetland areas would impair the ecological integrity of the wetland, no mechanical land clearing would occur in forested wetlands within the transmission line corridor. To minimize soil disturbance within forested wetlands, trees would be hand felled and stumps would remain in place. Additionally, no new access roads or towers would be placed within mature forested wetlands (as defined in Washington State Department of Ecology's Washington State Wetlands Rating System for Western Washington, Second Editions [August 1993, Publication 93-74]). Clearing activities would result in the loss of vegetation and other habitat features such as stumps, downed logs, and snags. Soil disturbance from these activities could injure or kill plants if large portions of the plant roots or aboveground shoots were cut or damaged. Soil disturbance from land clearing would result in an increase of sedimentation within wetlands and promote erosion on steep slopes common to the Brew Hill area. The removal of forested vegetation would also effect evapotranspiration rates and would increase soil and water temperatures due to the lack of shading.

The majority of new roads would be short spurs from the existing tower locations to the new adjacent tower locations. However, new road segments would be constructed within the new corridor to avoid potential wetland impacts that would occur from constructing roads within the existing corridor. On average, existing roads are 10-feet wide, and need to be widened to 16-feet wide. Road widening would consist of grading the current road surface and adding crushed rock 4 to 6 feet beyond the current road edge. Existing drainage devices such as water bars, and roadside ditches need to be replaced or repaired. Several culverts would be installed with the construction of new roads to facilitate drainage. The placement of impervious road surface in wetlands would impair the function to infiltrate surface water and discharge groundwater, alter surface and subsurface flows, destroy wildlife habitat, and result in increases in sedimentation and pollutants entering the adjacent wetland area.

Indirect impacts to wetlands could occur from construction activities adjacent to wetlands such as staging and material storage areas, work areas, the placement of tower footings, and construction or widening of access roads and spurs. Indirect impacts to wetlands and water resources from construction activities adjacent to wetlands could result in short-term increases in sedimentation and pollutants from ground disturbance and machinery operation, the removal of upland wildlife habitat, increases in surface water temperatures from the lack of vegetative shading, and the introduction of invasive plant species such as reed canarygrass and Douglas' spirea which already grow within the existing transmission line corridor.

Wetland Impact Avoidance and Minimization—Ecology and NEPA guidelines prioritize first reducing impacts through avoidance and minimization and then rectifying and compensating for unavoidable impacts. Criteria used by BPA to select the alternative ROW included avoiding known high-quality natural resources such as wetlands and streams. Any wetlands identified along the selected transmission line ROW would be avoided where feasible. Feasibility would be determined by land ownership, road configuration, spanning to avoid wetlands, construction costs, reducing sharp angles and bends in the ROW, and access.

Vegetation Impacts—Vegetation impacts from construction would include clearing shrubs, trees, and herbaceous vegetation from wetlands and wetland buffers. Vegetation within the construction ROW would be cut and removed, leaving roots intact where possible. Trees cut within and adjacent to forested wetlands would result in a permanent modification of that wetland type to either an emergent or shrub-scrub condition. Forested wetlands where vegetation would be permanently altered to shrub-scrub and emergent communities would experience greater impacts than other wetland areas. The low-growing vegetation within herbaceous and scrub-shrub wetlands is generally compatible with the vegetation height requirements for conductor clearance.

Hydrology Impacts—Construction-related activities could impact the hydrology of wetlands within and immediately adjacent to the cleared ROW and substation facilities. Construction could affect wetland hydrology by:

- Altering the subbasin that drains to a particular wetland by diverting surface and subsurface flows from grading and road construction;

- Altering evapotranspiration by modifying vegetation; and
- Increasing soil and water temperatures as a result of less shading.

Construction within or adjacent to wetlands associated with streams or other surface water could also adversely affect those surface water resources. Factors that determine the risk of altering wetland hydrology include the source of water for the wetland (e.g., groundwater, surface runoff, or streamflow), landscape position, size, surface geology, and soils.

Clearing tree cover would cause a high-level impact (as defined in Section 4.0) to forested wetlands. Tower and road construction would generally avoid wetland areas, which would allow hydric soils within forested wetlands within the ROW to be maintained. However, wetland hydroperiod (seasonal occurrence of flooding and/or soil saturation) would change with the removal of trees and resulting reduced evapotranspiration and forest litter; increased storm runoff volumes and delivery rates to adjacent waters would be expected (Reinelt and Taylor 1997).

Water Quality Impacts—The reduction in forested cover within wetlands and construction of new roads could result in degradation of water quality (Horner et al. 1997). Construction activities could introduce sediments into wetlands and thereby degrade the water quality of the wetlands if preventive measures are not taken. The most likely source of sediment would be construction of roads, staging areas, and excavation for tower footings. Construction of tower footings could require dewatering to maintain safe working conditions and conditions suitable for pouring the footings.

Wildlife Impacts—Removal of vegetation within and adjacent to wetlands could affect wildlife habitat and use in those wetlands. Because of the need to maintain low-growing vegetation for safety, the impacts to vegetative cover in forested wetlands would be more dramatic than the impacts to other wetland areas. The change in vegetative cover from trees and snags to low-growing scrub-shrub or emergent vegetation would impact wildlife species. Wildlife that depend on forested wetlands (e.g., cavity-dwelling birds and mammals) would be most impacted by construction due to loss of habitat (Richter and Azous 1997).

4.1.1.2 Mitigation

Standard mitigation measures to minimize wetland impacts include the following:

- Locate structures and new roads to avoid wetlands and buffers.
- Avoid any activities within designated King County wetland buffers (Ordinance #9614).
- Do not perform mechanized clearing within wetlands.
- Use helicopters during construction to minimize the need for use of roads and avoid impacts to wetlands.
- Limit disturbance to the minimum necessary when working in and immediately adjacent to wetlands.
- Locate construction staging areas outside of wetlands and associated buffers.
- Delineate wetlands before final design and flag for avoidance during construction.

- Use erosion control measures when conducting any earth disturbance upslope of wetlands to ensure soil is not washed downhill during storms.

- Ensure that the hydrology of wetlands and associated streams is maintained wherever the ROW crosses these resources. This can be accomplished by ensuring that landforms are regraded to pre-existing conditions, and that connectivity is maintained between streams and wetlands.

- Stockpile wetland topsoil when excavating and redeposit soil in place for restoration following construction.

- Minimize impacts to wetlands as described in WDNR Forest Practices Rules (WAC 222) regulations.

- Return temporary construction roads to their original contours following construction to reestablish pre-project surface water flow patterns.

- Ensure noxious weed infestations do not become a problem in wetlands by washing all construction vehicles and conducting a weed inventory one year after construction to verify that weeds have not been introduced.

- Avoid clearing vegetation within forested wetlands wherever possible.

- Use vehicle crossing mats to support equipment used during construction to minimize wetland soil compaction.

4.1.1.3 Cumulative Impacts

Filling or adverse modification of wetlands would result in the incremental reduction of wetland acreage and function within the watersheds of the project area. This could be offset through mitigation and restoration of degraded wetlands within the affected watersheds.

In the future, the transmission line ROW would be a logical choice for construction of other linear projects, including additional transmission lines, fiber optic cables, or pipelines. The decision to create a new corridor in this area could increase the likelihood of such proposals.

4.1.1.4 Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources

Unavoidable effects and commitment of wetland resources would be dependent on the final siting decisions for towers, roads, and other facilities. Siting of facilities to avoid wetlands could avoid or reduce the unavoidable, irreversible, or irretrievable effects.

4.1.2 Substation Impacts

4.1.2.1 Impacts

Expansion of the substation would impact less than 1 ac. of wetlands (Table 3).

Table 3. Acreage of Wetland Impact from Vegetation Clearing by Transmission Line Alternatives

Alternative	Acres of Wetland Impact
1	13.98[1]
2	14
3	6
4a	14
4b	15
Substation	< 1
[1]As calculated using wetland boundaries surveyed in December 2001.	

The wetland that would be affected is composed of a monotypic stand of sapling red alder. Wetland functions related to wildlife habitat, flood storage and flood flow moderation, and water quality improvement are low. Functional impacts to this wetland resulting from clearing would be minimal.

4.1.2.2 Mitigation

Wetland E-1 (Figure 3) is small and could be avoided. Mitigation would be the same as described in Section 4.1.1.2.

4.1.2.3 Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources

High-level impacts to wetlands from towers, roads, and expansion of the substation could be largely avoided.

4.1.3 Alternative Transmission Line Impacts

4.1.3.1 Alternative 1: Preferred Alternative

Impacts—The 150-ft.-wide ROW would require the clearing of 14 ac. of palustrine forested wetland area supporting tall growing woody vegetation (Table 3). Although the proposed 150-ft.-wide transmission line ROW would cross stream channels, valleys, and other landforms supporting wetlands, the conductor would span wetlands, and new structures and roads would be sited to avoid wetlands and streams. Wetlands surveyed within the Alternative 1 ROW consisted primarily of palustrine scrub-shrub and palustrine forested types. The majority of wetlands were low-gradient, depressional wetlands, however several seep wetlands are present on the south and north slopes of Brew Hill. Major streams and rivers associated with wetlands within the Alternative 1 ROW include the Raging River, Rock Creek, and Cedar River.

Clearing would cause a high-level impact to forested wetlands and their buffers. The permanent alteration of forested wetland community to scrub-shrub wetland community would degrade wildlife habitat, lower flood flow and flood storage capability, alter hydrology through changes in evapotranspiration rates, lower water quality improvement functions, and increase soil and water temperatures through the reduction of shading. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Alternative 1 has been designed so no fill would be placed within wetlands and streams during or following the construction of the transmission line, access roads, or the expanded substation. BPA engineers have determined that sufficient non-wetland areas are present to allow roads, staging areas, and tower locations for the project to be designed to avoid direct fill of wetlands and streams.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 1 would include:

- Towers should be sited to span the sinkhole associated with wetland 1-9, resulting in no clearing impact.

- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 1.

4.1.3.2 Alternative 2

Impacts—The 150-ft. wide cleared ROW would impact a total of 14 ac. of wetlands (Table 2). Wetland impacts associated with this alternative would include all of the wetland impacts described for the shared portion of Alternative 1. Additional impacts associated with Alternative 2 would result from the portion of the ROW originating from a tap point located approximately 2 mi. east of the tap point for Alternative 1 (S25, T22N, R7E), traversing approximately 3 mi. to S11, T22N, R7E, before continuing north along the same ROW as Alternative 1.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 2 would include:

- Towers should be sited to span the sinkhole associated with wetland 1-9, resulting in no clearing impact.

- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 2.

4.1.3.3 Alternative 3

Impacts—Along Alternative 3, wetland impacts were calculated for the 150-ft. wide ROW centerline and also for the remaining 350-ft. within a 500-ft. corridor (including 175 ft. west and 175 ft. east of Alternative 3). The 150-ft. centerline for Alternative 3 would impact a total of 6 ac. of wetlands (Table 2).

In comparison to the Alternative 3 centerline, if the transmission line were located in the corridor west of the centerline, a total of 10 ac. of wetlands would be impacted, 4 ac. more than the centerline. If the transmission line were located in the corridor east of the centerline, a total of 6 ac. of wetlands would also be impacted.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 3 would include:

- Towers should be placed to span wetland 3-9 at the crossing of Canyon Creek and vegetation clearing should be avoided within the wetland.

- Constructing the line in the 150-ft. ROW centerline would minimize clearing in wetlands, compared to placing the line in the western or eastern portions of the 500-ft. corridor.

- Utilizing the existing cleared ROW paralleling Pole Line Road would reduce the amount of tree removal and associated impacts.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 3.

4.1.3.4 Alternative 4a

Impacts—The 150-ft. wide ROW would impact a total of 14 ac. of wetlands (Table 2). Wetland impacts would include those described with the shared portions of the Alternative 1 ROW and the southern portion of the Alternative 2 ROW. Additional impacts associated with Alternative 4a were determined from 1 mi. of the ROW located between Alternatives 1 and 2. This portion of the ROW begins one-third of the way along Alternative 2 (S24, T22N, R7E) and connects with

Alternative 1 (S23, T22N, R7E) further south than where Alternative 2 reconnects (S11, T22N, R7E), before continuing north along Alternative 1.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 4a would include:

- Site towers to span the sinkhole associated with wetland 1-9, resulting in no impacts from clearing.
- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 4a.

4.1.3.5 Alternative 4b

Impacts—The 150-ft. wide ROW would impact a total of 14 ac. of wetlands (Table 2). Wetland impacts would include all of the wetland impacts described with the shared portions of the Alternative 1 ROW and the southern portion of the Alternative 2 ROW. Additional impacts associated with Alternative 4b would result from the portion of the ROW traversing between Alternatives 1 and 2 by paralleling Pole Line Road, before continuing north along Alternative 1.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 4b would include:

- Utilize the existing cleared ROW paralleling Pole Line Road, to reduce the amount of tree removal and associated impacts.
- Site towers to span the sinkhole associated with wetland 1-9, resulting in no impacts from clearing.
- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Unless wetlands are avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 4b.

4.1.3.6 Access Roads

Impacts—New access roads would be required to construct each of the alternatives. Where possible, new access roads would avoid identified wetlands for any of the proposed transmission line alternatives where practical.

New road construction could carry sediment into wetlands, affecting water quality and biological productivity. However, use of erosion and sediment control devices would minimize these impacts. Wetlands within the ROW and adjacent to access roads would be subject to soil compaction and vegetation damage from vehicles carrying heavy construction machinery and transmission line structures.

Mitigation—Mitigation measures specific to the construction of access roads within the project area would include:

- Utilize existing road systems to access tower locations and for the clearing of the transmission line ROW.
- Maintain properly functioning drainage control devices.
- Avoid construction on steep slopes and geologically unstable areas.
- Avoid constructing steep road grades.
- Construct roads consistent with the WDNR Forest Practices Rules (WAC 222).

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by the preferred alternative.

4.1.3.7 No Action Alternative

Current levels of impacts to wetland resources along the existing Raver-Echo Lake transmission line ROW would continue under the No Action Alternative.

4.2 Operation and Maintenance Impacts

4.2.1 Impacts Common to All Action Alternatives

4.2.1.1 Impacts

Maintenance of the 150-ft. transmission ROW and substations would require the periodic removal of trees to ensure a safe distance to the conductors. Tree clearing would be accomplished as routine maintenance in forested wetlands and their buffers where trees may grow to a height that conflicts with the operation of the transmission line.

Moderate-level wetland impacts would also occur where the forest cover was removed and permanently maintained as scrub-shrub or emergent vegetation.

4.2.1.1 Mitigation

Standard mitigation measures to minimize impacts to wetland resources during operation and maintenance of the transmission line would include:

- Require contractors to use manual methods within wetlands.
- Limit disturbance to the minimum necessary when working in and immediately adjacent to wetlands.
- Use erosion control measures when conducting any earth disturbance upslope of wetlands to ensure that soil is not washed downhill during storm events.
- Minimize impacts to wetlands consistent with the WDNR Forest Practices Rules (WAC 222) regulations.
- Avoid clearing vegetation within forested wetlands wherever possible.

4.2.1.2 Cumulative Impacts

Loss or modification of wetlands would result in an incremental reduction in wetland functions within the watersheds of the project area.

4.2.1.3 Unavoidable, Irreversible, or Irretrievable Impacts

Forested wetlands would be permanently modified through the removal of trees and maintenance of shrub-scrub wetland communities. Wildlife habitat, flood flow and flood storage moderation, and water quality functions would be permanently degraded. This commitment of wetland resources could occur in all watersheds crossed by the preferred alternative.

4.2.2 Access Roads

4.2.2.1 Impacts

Access roads used for maintenance of towers and the vegetation within the transmission line could carry sediment into wetlands, affecting water quality and biological productivity. Truck travel, exposed soil, and malfunctioning drainage control devices could result in low- to moderate-level impacts.

4.2.2.2 Mitigation

Mitigation measures specific to the operation and maintenance of access roads within the project area would include:

- Utilize existing road systems to access tower locations and for the clearing of the transmission line ROW.

- Maintain properly functioning drainage control devices on all roads.

- Repair degraded road surfaces.

- Decommission unused roads.

Please also refer to Section 4.2.1.2 for discussion of mitigation common to all action alternatives.

4.2.3 Substation

No additional wetland impacts would occur from the operation and maintenance of the substation.

4.2.4 No Action Alternative

Current levels of impacts to wetlands along the existing Raver-Echo Lake transmission line ROW would continue under the No Action Alternative. No impacts related to the proposed transmission line project would occur.

5.0 Environmental Consultation, Review and Permit Requirements

Several federal laws and administrative procedures must be met by the alternatives. This section lists and briefly describes requirements that could apply to wetland elements of this project.

5.1 Discharge Permits Under the Clean Water Act

5.1.1 Section 401

Section 401 of the CWA, the State Water Quality Certification program, requires that states certify compliance of federal permits and licenses with state water quality requirements. A federal permit to conduct an activity that results in discharges into waters of the United States, including wetlands, is issued only after the affected state certifies that existing water quality standards would not be violated if the permit were issued.

5.1.2 Section 402

The CWA Section 402 program, also known as the National Pollutant Discharge Elimination System (NPDES) program, regulates the discharge of pollutants from point sources into waters of the United States (other than dredged or fill material, which is covered under Section 404).

5.1.3 Section 404

Authorization from the Corps is required in accordance with the provisions of Section 404 of the CWA when there is a discharge of dredge or fill material into waters of the United States, including wetlands. This includes excavation activities that result in the discharge of dredged material that could destroy or degrade waters of the United States.

This project, with mitigation measures as stated, would meet the standards outlined by the CWA.

5.2 Other Standards and Guidelines

5.2.1 Cedar River Watershed Habitat Conservation Plan

The CRW HCP (City of Seattle 2000) was prepared by Seattle Public Utilities to establish a comprehensive plan for long-term management of the CRW. The HCP includes numerous provisions intended to protect wetlands and riparian habitat from degradation of function and ability to support species addressed in the HCP. Many of these provisions apply management procedures such as the designation of wetland reserve areas, and the establishment of adequate wetland buffers, as part of the Stream and Riparian Conservation Strategy component of the HCP. Specifically, the HCP allows timber harvest and road construction within wetlands and wetland buffers only in limited circumstances. For activities in wetlands and their buffers, the City of Seattle would consult with the state and federal agencies regarding measures to minimize and mitigate the impacts.

5.2.2 Washington Department of Natural Resources

The WDNR Forest Practices Rules (WAC 222) describe the types of forest practices allowed under the State of Washington Forest Practices Act (RCW 76.09). They divide forest practices into four classes based on potential impacts to public resources, and they classify wetlands as either Forested, Nonforested Type A, or Nonforested Type B. Specific wetland management zones and permitted practices within each management zone are applied to each wetland class.

5.2.3 King County Department of Development and Environmental Services

The King County Department of Development and Environmental Services reviews public and private projects under the King County Sensitive Areas Ordinance (Ordinance #9614) to ensure consistency with King County Code for project activities in wetlands and wetland buffers.

6.0 Individuals and Agencies Contacted

Agencies contacted include the Corps and the City of Seattle.

7.0 List of Preparers

David Johnson, Wetland Biologist
Two years of experience in wetland surveys, delineations, and mitigation and regulatory compliance and permitting.
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Five years of experience in wetland delineation and assessment of aquatic resources, resource inventory and classification, riparian and wetlands research, and permitting assistance.
M.S., Forestry (Riparian and Wetland Research Program), University of Montana, 1999.

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9.0 Glossary and Acronyms

This chapter contains a list of acronyms, abbreviations, and technical terms used in this report. Words that would be defined in a desk-size dictionary (for example, the College Edition of the American Heritage Dictionary) are not included.

Glossary

Access roads are constructed to each structure site first to build the tower and line and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, short spurs are built to the structure site. Access roads are maintained after construction, except where they pass through cultivated land where the road is restored for crop production after construction is completed.

Alternatives refer to different choices or means to meet the need for action.

Aquifers are water-bearing rock or sediments below the surface of the earth.

Best Management Practices are a practices or a combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Culverts are corrugated metal or concrete pipes used to carry or divert runoff water from a discharge. Culverts are usually installed under roads to prevent washouts and erosion.

Cumulative impacts are created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Cut and fill is the process by which a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (filled).

CWA signifies the Clean Water Act, a federal law intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters and secure water quality.

Danger trees or high-growing brush occur in or alongside the project right-of-way and are hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owner of danger trees off the right-of-way is compensated for their value. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories: Category A contains any tree that in 15 years will grow within about 5 m (18 ft.) of conductors when the conductor is at maximum sag (100^o C or 212^o F) and is swung by 30 kg per sq/m (6 lb per sq/ft.) of wind (93 kph or 58 mph); Category B represents any tree or high-growing bush that after 8 years of growth will fall within about 2 m (8 ft.) of the conductor when it reaches maximum sag (80^o C or 176^o F) in a static position.

Dead ends are heavy towers designed for use where the transmission line loads the tower primarily in tension rather than compression. Dead ends are used in turning large angles along a line or in bringing a line into a substation.

Easement is a grant of certain rights to use a piece of land, which then becomes a "right-of-way." BPA normally acquires easements for its transmission lines. Easement includes the right to enter the ROW to build, maintain, and repair facilities.

Emergent plants have their bases submerged in water.

Endangered species are those officially designated by the USFWS and/or the NMFS as being in danger of extinction throughout all or a significant portion of their range.

Floodplain refers to a portion of a river valley adjacent to the stream channel that is covered with water when the stream overflows its banks during flood stage.

Footings are the supporting base for the transmission towers. They are usually steel assemblies buried in the ground for lattice-steel towers.

Forb is any herbaceous plant that is not a grass or grasslike.

Ford is a travelway across a stream where water depth does not prevent vehicle movement. Ford construction can include grading and stabilizing streambanks at the approaches and adding coarse fill material within the channel to stabilize the roadbed.

GIS signifies Geographic Information System, a computer system that analyzes graphical map data.

Ground wire (overhead) is wire strung from the top of one tower to the next; it shields the line against lightning strikes.

Hydrology addresses properties, distribution, and circulation of water.

Hydroperiod is the seasonal occurrence of flooding and/or soil saturation.

Insulators are ceramic or other nonconducting materials used to keep electrical circuits from jumping to ground.

Intermittent refers to periodic water flow in creeks or streams.

Jurisdictional wetlands are areas that are consistently inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Kilovolt is one thousand volts.

Lattice steel refers to a transmission tower constructed of multiple steel members that are connected together to make up the tower's frame.

Low-gradient refers to gentle slopes.

Mitigation is the step(s) taken to lessen the potential environmental effects predicted for each resource impacted by the transmission project. Mitigation may reduce the impact, avoid it completely, or compensate for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is enacted during the design and location process. Other mitigation, such as reseeding access roads with desirable grasses and avoiding weed proliferation, is taken after construction.

National Environmental Policy Act (NEPA) requires an environmental impact statement on all major federal actions significantly affecting the quality of the human environment.
(42 U.S.C. 4332 2(2)(C))

Noxious weeds are plants that are injurious to public health, crops, livestock, land, or other property.

100-year floodplains are areas that have a 1% chance of being flooded in a given year.

Perennial streams and creeks have year-round water flows.

Permeability refers to the capability of various materials to transport liquids.

Pulling site is a staging area for machinery used to string conductors.

Revegetation is reestablishment of vegetation on a disturbed site.

Right-of-way (ROW) is an easement for a certain purpose over the land of another owner, such as a strip of land used for a road, electric transmission line, pipeline, etc.

Riparian habitat is a zone of vegetation that extends from the water's edge landward to the edge of the vegetative canopy. The term is associated with watercourses such as streams, rivers, springs, ponds, lakes, or tidewater.

Sensitive species are those plants and animals identified by the USFWS for which population viability is a concern. This classification is evidenced by significant current or predicted downward trends in populations or density and significant or predicted downward trends in habitat capability.

Silt is a designation referring to individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05 mm).

Substation is the fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Threatened species are those officially designated by the USFWS as likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Transmission line includes the structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Water bars are smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

Wetlands are areas where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Acronyms and Abbreviations

ac.	acre or acres
BMPs	Best Management Practices
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
Corps	U.S. Army Corps of Engineers
CRW	Cedar River Watershed
CWA	Clean Water Act
ft.	foot or feet
Ecology	Washington Department of Ecology
EIS	environmental impact statement
EPA	Environmental Protection Agency
GIS	Geographic Information System
HCP	Habitat Conservation Plan
in.	inch or inches
kV	kilovolt
mi.	mile or miles
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NWI	National Wetland Inventory
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
ROW	right-of-way
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WRIA	Water Resource Inventory Area

Appendix F Geology, Soil, Climate and Hydrology Technical Report

Bonneville Power Administration
Kangley – Echo Lake Transmission Project
Geology, Soil, Climate, and Hydrology
Technical Report

January 2001

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21-1-09189-001

Executive Summary

This technical report presents information regarding existing geologic, soil, climatic and hydrologic conditions and natural hazards that could impact or be impacted by construction and operation of one of five proposed electrical transmission line routes. The new transmission line would tap the existing Schultz-Raver No. 2 500-kV transmission line near the community of Kangley. From the tap it would proceed north about 10 miles to the Echo Lake Substation. The route alternatives include options that (1) parallel the existing Raver-Echo Lake 500-kV transmission line, (2) follow a new right-of-way (ROW), and (3) combinations of new ROW and parallel to the existing ROW. We understand that the information provided in this report may be used in part to select a preferred route and to prepare a Draft Environmental Impact Statement.

Chapter 1 of this report presents an overall description of the project, project scope and methods of study. Chapter 2 summarizes the route alternatives and the proposed Echo Lake Substation improvements.

The affected regional environment is discussed in Chapter 3, which includes sections on topography, geology, soils, seismology, hydrology, and wind. In general, the region has moderately rugged topography and is underlain by glacial deposits and by sedimentary and volcanic rock that has been folded and faulted. The affected environment discussion for each of the five route alternatives includes information on major drainages, bedrock and surficial geology, and local topography.

Chapter 4 presents an overview of the resources and natural hazards evaluated, including shallow and deep-seated landslides, soil erosion, settlement, liquefaction, faulting, flooding, and water-quality limited (303[d] listed) water bodies. Each resource was assigned ratings of no, low, moderate, or high impact. Following the overview, Chapter 4 discusses the impacts, mitigation, cumulative impacts and unavoidable effects, irreversible or irretrievable commitments of resources along each of the proposed alternative alignments.

Chapter 6 provides a description of the review and permit requirements related to the resources discussed in this technical report.

Shannon and Wilson, Inc. has included “Important Information About Your Geotechnical Report” (Appendix A) to assist you and others in understanding the use and limitations of our report.

The affixing of the professional seal below indicates the exercise of professional judgement by participation in developing the engineering and geological matters embodied in our work for this project.

SHANNON & WILSON, INC.

Jeffrey R. Laird
Principal Engineering Geologist

Christopher A. Robertson, P.E.
Associate

JRL:CAR:WTL/jrl

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Bonneville Power Administration
Kangley - Echo Lake Transmission Project
Geology, Soil, Climate And Hydrology
Technical Report

Chapter 1 Introduction

This technical report describes geologic, soil, climatic conditions and hydrologic and natural hazards that are present along the five proposed route alternatives of the Bonneville Power Administration (BPA) Kangley - Echo Lake Transmission Project. It also identifies potential impacts that could result because of construction, operation, and maintenance of the project. The information from this report will be used to prepare portions of an Environmental Impact Statement (EIS) for the proposed project.

1.1 Project Description

The BPA is proposing to build a new 500-kilovolt (kV) transmission line that would connect an existing transmission line (near the community of Kangley) with BPA's existing Echo Lake Substation in King County, Washington. The Vicinity Map, Figure 1, shows the project location. The Project Area Plan, Figure 2, shows the approximate locations of the route alternatives. The new transmission line will be about 10 miles long, depending on the route alternative selected. BPA's primary reason for building the proposed new transmission line is to improve system reliability in the King County area. Under normal growth in demand, system instability could develop as early as the winter of 2002-2003 with an outage of the existing Raver-Echo Lake 500-kV line. Another reason is to enhance the United Sates' delivery of power to Canada as required under the Columbia River Treaty of 1961.

BPA is considering five alternative routes. All routes are east of the existing Raver-Echo Lake 500-kV line that runs between the Raver and Echo Lake Substations, and would cross portions of the Cedar River Municipal Watershed. Once the environmental review is complete, BPA will decide whether and how to proceed with the project. If BPA decides to proceed, construction could begin in 2002.

The proposed project has two major elements, which are:

1. A new 500-kilovolt (kV) transmission line; and
2. An expansion to the existing Echo Lake Substation to accommodate the new transmission line.

Section 2.0 of this report describes the route alternatives and substation improvements that are included in this study. This study consisted of a review of existing data, including reports and aerial photographs, and site reconnaissance along the proposed alternative routes.

Chapter 2 Proposed Action and Alternatives

The proposed new 500-kV transmission line will follow one of five alternative routes that would be on new right-of-way (ROW), east of and next to the existing Raver – Echo Lake 500-kV transmission line, or a combination of these two. The five alternative routes shown on the Project Area Plan, Figure 2, are:

Alternative 1 would be east of and parallel the existing Raver-Echo Lake 500-kV transmission line for its entire length. The new transmission line would tap the Schultz-Raver No. 2 500-kV transmission line about 2.8 miles northeast of the Raver Substation. From the tap, the new line would proceed north-northeast for about 2.9 miles to an existing angle tower, and then continue north for about 6 miles to the Echo Lake Substation. The route would cross the Cedar River about 1.8 miles from the tap. The first 1.2 miles would cross mostly private land and then enter the Cedar River Watershed. It would proceed through the watershed for about 4 miles. After leaving the watershed, the route would cross private residential land, private timberland and State of Washington Department of Natural Resources (DNR) timberland.

Alternative 2 would tap the Schultz-Raver No. 2 line about 1.75 miles east of where Alternative 1 would tap this line and proceed north-northwest to the existing Raver-Echo Lake 500-kV transmission line. From the tap, it would cross private timberland for about 0.6 miles where it would enter the Cedar River Watershed. Alternative 2 would cross the Cedar River about 1.7 miles northeast of the tap and about 0.7 miles east of where Alternative 1 would cross the river. Approximately 3 miles northeast of the tap, Alternative 2 would meet the existing Raver-Echo Lake 500-kV transmission line near an existing angle tower, and then proceed north to the Echo Lake Substation following the same route as Alternative 1.

Alternative 3 would tap the Schultz-Raver No. 2 line about 1.75 miles east of where Alternative 1 would tap this line and proceed north-northwest for about 1.7 miles until it meets Pole Line Road in the Cedar River Watershed. From there the new transmission line would follow Pole Line Road on the southeast side for about 2.0 miles. Then the line would turn northwest and proceed in a straight line to the Echo Lake Substation. After about 0.2 miles from Pole Line Road, the route would cross the Cedar River. Approximately 2 miles northwest of Pole Line Road, the route would leave the Cedar River Watershed. The next 4.4 miles to the Echo Lake Substation would cross mostly private timberland, some DNR timberland, and possibly some private residential land.

Alternatives 4A and 4B would initially follow Alternative 2 and then would proceed west or northwest into the Cedar River Watershed to where they would connect with Alternative 1 before crossing the Cedar River. Both alternatives would then follow the Alternative No. 1 route to the Echo Lake Substation. Alternative 4A would leave the Alternative 2 route after 0.9 miles and join Alternative 1 about 1.6 miles north-northeast of where Alternative 1 would tap the Schultz-Raver No. 2 line. This route segment likely would have one angle about ½-mile northeast of where it leaves the Alternative 2 route. Alternative 4B would leave the Alternative 2 route about 1-1/3 miles north of the tap point of the Schultz-Raver No. 2 line, and then follow

Pole Line Road west to where it intersects Alternative 1. The intersection would be about 1¼-mile north of where Alternative 1 would tap the Schultz-Raver No. 2 line.

The Echo Lake Substation would be expanded to accommodate the proposed new 500-kV transmission line. The Echo Lake Substation improvements will include clearing and leveling an area east of and adjacent to the existing substation. The new substation plan area would be approximately 250 feet in an east-west direction by 750 feet in a north-south direction. The finished surface would be covered with gravel to reduce erosion. While most of the existing substation is in a relatively flat area, the new portion would be on a slope that rises to the east at an average grade of 5 to 10 percent. A cut slope was made on the east side of the existing substation during the original construction. We understand the new construction would require an additional 10- to 15-foot deep cut.

Currently, Road No. 35000 is on the east of the existing substation within the site proposed for the new substation. Therefore, the road would need to be relocated at least 250 feet further east. We estimate that approximately 1500 lineal feet of new road would be required.

2.1 Right-of-Way Clearing

Initially, a strip of land about 150 feet wide would be cleared in the transmission line ROW to allow for tower construction and conductor clearance. Trees would then be allowed to grow to maturity along the outer 35 to 90 feet of the alignment corridor edge. The clearing and regrowth of trees along the edge is to allow the new trees to become established under the new, more open, conditions. Modern logging methods, including the use of cable logging and low ground pressure equipment, would be used to reduce the amount of access road building and ground disturbance.

Disturbance of the soil cover during logging would be reduced using appropriate logging methods. A low ground cover of vegetation consisting of shrubs and grasses will remain following logging and the cleared area would not be burned. Over the years, this vegetation will grow to a taller and denser condition. Consequently, the benefits of vegetation, including root strength, soil cover, interception of precipitation, and evapotranspiration would remain to some extent.

2.2 Transmission Line

BPA proposes to use single-circuit steel lattice towers to support the new transmission line. Typical transmission line tower spacing will be about 1,100 to 1,200 feet, except where longer spans are required to cross streams such as the Raging River and the Cedar River. The exact tower locations would be determined after the preferred alternative is selected.

Stable foundations for the transmission line towers and substations are necessary to reduce the potential for structure failures. The towers and their foundations would be designed and constructed to withstand the structural dead loads and live loads from wind and earthquakes.

Site investigations should be conducted to evaluate subsurface conditions so that adequate foundations can be designed and constructed.

In general, foundations would consist of steel plates that are buried in excavations averaging 15 feet deep. Soil would be backfilled and compacted over the plates. Where soil depths are shallow and hard or massive rock is encountered, the towers would be anchored to the rock using rock dowels.

In general, the proposed tower locations do not include areas of deep, soft ground where settlement and liquefaction are concerns; unstable slopes in streams or other water bodies; or floodplains. Therefore, special foundations, such as driven piles, drilled concrete piers, or soil anchors should not be required.

2.3 Access Roads

BPA normally acquires rights and develops and maintains permanent access for travel by wheeled vehicles to each structure. Access roads are designed for use by cranes, excavators, supply trucks, boom trucks, and line trucks for construction, ROW clearing, and maintenance of the transmission line. BPA prefers road grades of 6 percent or less in areas of highly erodible soils and 10 percent or less for erosion resistant soils. For short distances, maximum acceptable road gradients are 15 percent for trunk or main roads and 18 percent for spur roads (roads that go to each structure if the structure is not on a trunk road). The locations and lengths of new trunk and spur access roads that would be required for each Alternative have not yet been determined. These will be determined after a preferred alternative is selected.

Best Management Practices (BMPs) are used in constructing and upgrading access roads, as described in Section 4. New or existing trunk access roads are surfaced with gravel for construction and maintenance activities. Water bars are usually installed on trunk roads after construction. Trunk and spur access roads are revegetated after construction.

Regardless of the alternative selected, much of the new transmission line could be built using the existing access road system owned by King County, Seattle Public Utilities (SPU), private timber company and BPA. This existing system includes trunk and spur logging roads, trunk and spur access roads for the Cedar River Watershed, and farm and residential roads to the communities of Kangley, Selleck, and Halmar Gates.

New trunk roads may be required depending on the alternative selected. Easements for new trunk roads built outside the ROW would be 50 feet wide. New or existing trunk roads would be graded to provide a 14-foot wide travel surface, with an additional 4 to 6 feet on curves. About 10 feet on both sides of a trunk road would be graded for ditches, etc., for a total clearing width of 24 to 30 feet. The road surface is usually surfaced with gravel for construction and maintenance activities.

New spur roads will be required to access most tower locations. Spur roads would be built within the ROW from the on-ROW trunk roads to access structures.

Chapter 3 Affected Environment

The topography, geology, and soils of the project area are key factors that affect the susceptibility of different areas to erosion and sedimentation. Erosion and sedimentation can cause degradation of water quality and affect fisheries and other habitat. Landslides, soil creep and other mass wasting processes can contribute to hillslope erosion and stream sedimentation. Logging, ROW clearing, road and tower construction, use, and maintenance can affect these processes. The following sections describe the topography, geology, and soil types present within the project area.

3.1 Topography

The project area can be subdivided into two physiographic provinces: a southern lowland area in Green Valley and a northern mountainous area, which includes Taylor Mountain, Brew Hill, Rattlesnake Mountain, and the intervening Raging River valley (Rosengreen, 1965). As described in Section 3.2, Geology, both areas are underlain by glacial drift. Bedrock outcrops are limited almost entirely to the northern mountainous area. The Geologic Map, Figure 3, shows topographic contours and the locations of the surficial bedrock and glacial units in the project area. The Slope Map, Figure 4, shows areas with slopes between 0 and 15 percent, 15 and 40 percent, 40 and 65 percent, and steeper than 65 percent.

The southern lowland area consists of a series of glaciofluvial terraces that are cut by abandoned, Vashon Stade glacial meltwater channels and more recent streams, including the Cedar River and other smaller streams, such as Taylor, Williams and Steele Creeks. The terraces consist of nearly flat to rolling drift plain with low elongated ridges that typically have less than 200 feet of relief. In the project area, the terraces range in elevation from 800 feet near the Cedar River to about 1,000 feet adjacent to the northern mountainous area. The terraces are somewhat higher in elevation to the south, rising to about 1,600 feet 1 mile southeast of the project area. An area of complex topography is present on the western edge of the project area between the Cedar River to the south and the northern mountainous area to the north. This area includes several small lakes, bogs and sinks that were formed by outwash sediment deposited around stagnant ice that remained after the glacier had retreated.

The Cedar River is the principal stream in the southern lowland area. Its headwaters are east and southeast of the project area and the river flows generally northwest to Renton, where it discharges into Lake Washington. The Cedar River enters the east side of the project area at about elevation 880 feet and leaves the western edge of the project area at about elevation 700 feet. It has an average gradient of about 38 feet per mile (0.7 percent). The Cedar River and other streams have incised into the glaciofluvial terraces, locally exposing older glacial deposits and bedrock, and creating steep-walled gorges. The Cedar River floodplain in the study area is narrow, but does contain lateral and center channel gravel bars.

The northern mountainous area consists of relatively low rounded mountains with moderate slopes and intervening valleys. The Vashon Stade continental glacier overrode almost the entire area, eroding the mountains and depositing a mantle of glacial till and outwash. At the maximum glacial stand, only the highest points of Rattlesnake Mountain emerged above the glacial ice. Rattlesnake Mountain is the highest point adjacent to the project area, with a summit elevation of 3,517 feet.

The Raging River is the principal stream in the northern mountainous area. It flows north through a broad, glacially carved, U-shaped valley between Brew Hill and Taylor Mountain to the west and Rattlesnake Mountain to the east. The head of this U-shaped valley forms a broad pass between the Cedar River to the south and the Raging River to the north at about elevation 1,500 feet. The upper reaches of the Raging River are moderately incised into the U-shaped valley. Near the end of an old railroad grade at Kerriston, the Raging River becomes more deeply incised, with steep valley walls as high as 200 feet. Several smaller streams drain to the south into the Cedar River, including Rock, Williams, and Steele Creeks. These streams typically are deeply incised except where they cross gently sloping terraces of the southern lowland area.

3.2 Geology

The project area is located along the western margin of the South Cascade Range (Galster and others, 1989). The South Cascades are composed primarily of Tertiary age volcanic, volcaniclastic and associated sedimentary rocks. These rock units have been folded and faulted since they were deposited. Repeated advances of continental glacial ice sheets into the Puget Sound lowlands during the Quaternary have eroded the Cascade foothills and deposited thick sequences of glacial sediments. The geology along the alternative alignments is shown on the Geologic Map (see Figure 3). Table 1 presents descriptions of the geologic units that are present along the alternative alignments. The map and descriptions of the geologic units are based on published geologic maps, and on the aerial photographic mapping and ground verification described in Section 7.0.

3.2.1 Tertiary Geology of the Project Area

The Tertiary age rocks that are exposed in the project area have been subdivided into a group and several formations. The following paragraphs describe each rock unit from oldest to youngest.

The oldest rocks exposed in the project area are the late early to middle Eocene (43 to 54 million years before present {mybp}) rocks of the Raging River Formation (Vine, 1962). These rocks are an estimated 3,000 feet thick and consist of volcanic sandstone, siltstone and conglomerate that were deposited in a nearshore marine environment. Frizzell and others (1984) show one area where the Raging River Formation outcrops in the project area in Section 14, about one mile southwest of the Echo Lake Substation (Unit Trr on Figure 3).

Nonmarine volcanic and sedimentary rocks of the 11,000-foot thick, middle to late Eocene Puget Group conformably overlie the Raging River Formation (Frizzell and others, 1984).

These rocks were deposited primarily in fluvial environments and to a lesser extent in nearshore marine environments. The rocks include sandstone, siltstone, claystone and coal. The sandstone is generally massive to cross bedded, with occasional channel cut-and-fill structures. The Puget Group has locally been divided into several formations, which include from oldest to youngest, the Tiger Mountain, Tukwila, and Renton Formations. The following paragraphs describe each of these formations. Numerous outcrops of the Puget Group that have not been differentiated into formations are present within the project area north of the Cedar River (Unit Tpg on Figure 3).

The late early to middle Eocene (43 to 54 mybp), 2,000-foot thick, Tiger Mountain Formation consists of medium-grained sandstone with interbedded siltstone, conglomerate and coal beds (Vine, 1962). Clay minerals represent about 10 percent of the rock volume and provide the matrix in these clastic rocks. The Tiger Mountain Formation outcrops along the north half of the Alternative 1 alignment (Unit Tptm on Figure 3).

The upper portion of the Tiger Mountain Formation is interbedded with volcanic rocks of the conformably overlying Tukwila Formation (Vine, 1962). The middle to late Eocene (36 to 50 mybp) Tukwila Formation is composed of volcanic lava flows, sills and dikes, breccia, conglomerate and sandstone. Volcanic tuff and breccia probably makes up most of the Tukwila Formation, but the volcanic flow rocks are more resistant to erosion, thereby forming much of the visible outcrop. Tukwila Formation rocks are exposed along the west flank of Rattlesnake Mountain, east of the Alternative 3 alignment, and along the north side of the Cedar River across the Alternative 3 alignment (Unit Tpt on Figure 3).

The youngest rocks in the Puget Group, the late Eocene Renton Formation (Vine, 1962) conformably overlie the Tukwila Formation. The Renton Formation is as thick as 2,250 feet and consists of sandstone, siltstone, claystone and coal. This formation was deposited in fluvial and nearshore marine environments. Clay commonly cements the sandstone. Fine-grained, interbedded siltstone and claystone commonly form valleys between more resistant sandstone ridges. Renton Formation outcrops just to the west of the approximate center of the Alternative 1 alignment (Unit Tpr on Figure 3). Historic coal workings exist in the Renton Formation on the south flank of Brew Hill, west of the Alternative 1 alignment (Walsh, 1984).

Volcanic rocks of the late Oligocene (25 to 35 mybp) Huckleberry Mountain Formation unconformably overlie the older Puget Group and Raging River Formation. These rocks consist of generally well-bedded andesite and basalt breccia, tuff and lava flows with minor amounts of volcanic sandstone, siltstone and conglomerate. Huckleberry Mountain Formation outcrops more than 1.2 mile south of the Pole Line Road portion of section Alternative 3 and south of where Alternatives 2 and 3 would tap the Schulz-Raver No. 2 line (Unit Thm on Figure 3). These rocks probably would not be encountered during construction and maintenance of either Alternative 2 or 3.

The youngest rocks exposed in the project area consist of igneous intrusions into Puget Group rocks. Frizzell and others (1984) describe two outcrops of intrusive rock. Diabase and gabbro (Unit Tdg on Sheet 3 of Figure 3), which are dark-colored, igneous intrusive rocks, form the resistant ridge west of Alternative 1, 3,000 to 4,000 feet north of where it would tap the

Schulz-Raver No. 2 line. The second outcrop consists of early to middle Miocene (18 to 25 mybp) tonalite (Unit Tit on Sheet 1 of Figure 3), which is an igneous intrusive rock similar in appearance to granite. This outcrop is located about 2.4 miles south of the Echo Lake Substation and 1,000 feet west of Alternative 1. It is possible that these rocks would be encountered during construction and maintenance of Alternative 1.

3.2.2 Quaternary Geology of the Project Area

Geologic processes profoundly influenced the surficial deposits and landforms in the project area during the Quaternary Period (present to 2 mybp). With the exception of the highest portions of Rattlesnake Mountain, the entire project area was overridden by continental glacial ice during the Pleistocene Epoch 10,000 years ago to 2 mybp. The continental glacier deposited variable thicknesses of glacial till and glacial outwash in the northern mountainous area. In the southern lowland area, the glaciers deposited extensive glaciofluvial and ice-contact deposits, and reshaped the surface with a series of meltwater channels that formed beneath and in front of the ice sheet and as the continental glacial ice retreated. Following glacial retreat, the landforms were locally modified by fluvial erosion and deposition and mass wasting.

3.2.2.1 Pleistocene Glacial Geology

At least six periods of continental glaciation have been documented in the Puget Lowland and adjacent margins of the Cascade and Olympic Mountain Ranges. However, evidence of only the most recent period, termed the Vashon Stade (which occurred between 15,000 and 13,500 years ago in the central part of the lowland), has been described in the project area (Rosengreen, 1965). Each advance and retreat of an ice sheet may be characterized by a complex sequence of glaciolacustrine sediments, glaciomarine drift, advance outwash, till and recessional outwash. Erosion and deposition of the glacial sediments between each glacial interval have altered these deposits. The total thickness of these Pleistocene deposits can range between 0 and 3,700 feet in the Puget Lowland.

During the Vashon Stade of the Fraser Glaciation, the Puget lobe of the glacier flowed southeast across the northern mountainous area, covering and reshaping all but the highest points of Rattlesnake Mountain. The upper limits of ice can be determined from the highest presence of glacial till and erratic boulders. The glaciers advanced across the southern lowland area, terminating against mountains south of Green Valley. As the glaciers advanced over the area, they eroded the underlying bedrock, shaping streamlined, molded forms. A mantle of lodgment till (Unit Qvt on Figure 3), which consists of subangular to rounded gravel-, cobble- and boulder-sized clasts supported in a matrix of dense silt and sand, was deposited at the base of the glacier. Lodgment till is the most prevalent Quaternary deposit in the northern half of the project area along Alternative 1 and 3 alignments (Unit Qvt on Figure 3).

The glacier blocked the Snoqualmie and Cedar Rivers, diverting the drainage along the eastern ice margin. Meltwater from these drainages flowed along the margin of the ice, south of the current Cedar River, until it entered the valley currently occupied by Taylor Creek. It flowed southeast to Eagle Gorge, and then flowed northwest down the Green River to Kankaskat. From Kankaskat, meltwater continued south along the ice margin against the western Cascade foothills. Ultimately the meltwater reached the Chehalis Valley, which was the principal outflow channel beyond the glacier terminus. At the maximum stand, ice-contact deposits, consisting of stratified sand and gravel, silt, clay and glacial till were deposited along the glacial margin. Stagnant ice that was covered with ice-contact deposits subsequently melted causing collapse features such as kettles. Ice-contact deposits are widespread along the west and south slopes of Taylor Mountain. Alternative 1 crosses ice-contact deposits north of the Cedar River (Unit Qvi on Figure 3).

As the glacier receded, a series of meltwater channels developed as the ice front successively moved to the northwest. Meltwater streams deposited recessional outwash consisting of stratified sand and gravel. Rosengreen (1965) describes seven stages of the recessional history. The geologic map by Frizzell and others (1984) includes numbering of these stages, with 1 being the oldest (e.g., unit Qvr1 on Figure 3). Several of these stages occur in the project area as successive outwash terraces that formed as meltwater channels incised into previous terraces and successive deposits of ice-contact sediments. Glacial lakes formed periodically along the Raging River, dammed by the ice margin to the north. Rosengreen (1965) describes glaciolacustrine deposits near Kerriston, and west of the Echo Lake Substation. The glaciolacustrine deposits consist of well-stratified sand and silt, with a few thin lenses of gravel. These glaciolacustrine deposits typically have a limited aerial extent. As such, they are not included in the geologic mapping by Frizzell and others (1984), and are not represented on Figure 3 or on Table 1.

3.2.2.2 Holocene Geology

Holocene deposits include landslides, colluvium, bogs, alluvium, and volcanic ash. Landslide deposits result from the relatively rapid downslope movement of rock and soil, and are generally found on and at the base of hillslopes. They usually consist of a remolded, heterogeneous mixture of several soil types and commonly include organic debris. Frizzell and others (1984) describe a large, ancient, deep-seated landslide complex in the approximate center of the Alternative 1 alignment (Unit Qls on Figure 3). As described in the following section, landslides are relatively uncommon in the project area.

Colluvium is soil that has been transported downslope, generally by mass wasting processes, including shallow landsliding, rainsplash erosion, and soil creep. It generally develops on slopes and near the base of a slope. The thickness can range from a few inches to 10 feet or more, with the thickness usually increasing downslope. Colluvium is relatively widespread in the study area, as described in Section 3.3; however, the unit is generally not shown on geologic maps because it is relatively thin.

Bog deposits include peat and organic with lacustrine deposits (Unit Qb on Figure 3). They occur in poorly drained, low-lying areas, such as the broad pass near Halmar Gate, and in areas where stagnant ice was present, such as the ponds and sinkholes north of the Cedar River and east of Alternative 1. Bog deposits typically are in areas currently designated as wetlands can provide poor foundation conditions.

Rivers and streams deposited alluvial sediments in and adjacent to current and historical channels. Alluvium includes fine-grained, overbank deposits and coarse-grained channel deposits. Older alluvial deposits are present along the Cedar River in the form of low, discontinuous terraces (Qa on Figure 3) that were deposited after the continental glaciers had fully retreated. The terraces formed as the Cedar River eroded and incised a deeper channel, leaving remnants of the alluvial deposits along the valley sides. The alluvium consists of medium dense, moderately well sorted, cobble and gravel deposits. Recent alluvial deposits occur in and adjacent to the streams and rivers in the project area in the forms of sand, gravel and cobble bars, and alluvial fans.

Volcanic ash was widely deposited over most of western Washington as a result of the catastrophic eruption of Mount Mazama in southern Oregon approximately 6,600 years ago and other less extensive volcanic eruptions. The deposits are well preserved in bog deposits. Elsewhere, they typically are mixed with other soil types.

3.2.2.3 Landslides

Few landslides are identified in the published geologic maps of the project area. We did not identify landslides during our field reconnaissance or photogeologic studies that were not already identified in published literature. The paucity of landslides is probably due to the relatively gentle to moderate slopes, and relatively stable geologic conditions.

Deep-seated landslides can range in depth from 10 feet to more than 100 feet and may involve movement of bedrock and soil. Deep-seated landslides generally initiate as a single mass movement that may then separate into discrete blocks. Typically, deep-seated landslides have a zone of weakness, such as a layer of clay or weak rock, where a landslide slip surface forms. Landslide movement is usually initiated by:

- Excessive pore water pressure in the landslide mass, such as during wet storm periods.
- Removing support from the toe of the landslide by stream erosion or excavation for a road or other feature.
- An increase of driving forces at the top of the landslide. Typically, this occurs when a fill is placed on the slope for construction of a road or other structure.
- Strong ground motions during an earthquake. The large, ancient deep-seated landslide on the Alternative 1 alignment may have been initiated during a large-magnitude earthquake.

Shallow landslides are normally less than 10 feet deep and occur in soil and highly weathered bedrock. Shallow landslides typically occur on slopes that are steeper than 65 percent (33 degrees), although they can occur on much flatter slopes under certain conditions. Shallow landslides usually occur during periods of intense and/or prolonged precipitation. Other factors that contribute to shallow landslides include changes that tend to increase the steepness of a slope, such as erosion or excavation of soil at the toe of the slope or placing fill on a slope. Poorly compacted road fills are particularly susceptible to shallow landsliding. Stormwater runoff that discharges as concentrated flow on a slope can contribute to instability both by causing erosion that oversteepens a slope and by increasing the pore water pressure in the slope soils.

3.2.3 Geologic Structure

The geologic structure of the project area is dominated by a broad zone of northwest-southeast trending faults and folds that comprise the Olympic-Wallowa Lineament (Frizzell and others, 1984). The once near-horizontally bedded, sedimentary rocks have been uplifted and folded, tilting the bedded rock in various directions and at various angles. Two major folds are present in the project area, the Rattlesnake Mountain syncline and the Raging River anticline, as shown on the Geologic Map, Figure 3. A syncline is a fold where the rock layers dip towards the axis or center of the fold. The surface of a rock layer in a synclinal fold forms a concave-upward surface. An anticline is the opposite of a syncline. That is, the rock layers dip away from the axis of the fold, such that rock layers form convex-upward surfaces. The axis of the Raging River anticline follows the Raging River Valley south to just west of Brew Hill. In general, rock layers west of the Raging River dip down to the west and southwest at angles of 25 to 50 degrees. East of the Raging River, rock layers generally dip down to the east and southeast at angles of 30 to 60 degrees. The axis of the Rattlesnake Mountain syncline is east of the project area on the east flank of Rattlesnake Mountain. Rock layers east of the synclinal fold axis dip down 60 to 65 degrees to the west.

Previous workers have mapped several faults in and adjacent to the project area (Frizzell and others, 1984; Phillips; 1984; and Walsh, 1984). These faults generally trend northwest to north-northwest. The fault planes are apparently high angle, and most displacement is vertical. From east to west, these include the Rattlesnake Mountain, Raging River, and Piling Creek Faults, as shown on Figure 3. The Piling Creek Fault is the southeastern extension of the Hobart Fault. The age of the faulting is uncertain; however, Gower and others (1985) found that movement on the Rattlesnake Mountain and Piling Creek Faults is not older than the Miocene – Oligocene boundary (24 mybp). Gower and others (1985) do not present information regarding the age of the Raging River Fault. There is no published evidence of recent movement on these faults or that these faults offset Pleistocene or Holocene sediments.

The Rattlesnake Mountain fault is located east of the project area, mostly on the east flank of Rattlesnake Mountain. The fault movement has displaced Tiger Mountain Formation rocks down to the east and against younger Oligocene Rattlesnake volcanic rocks. North of the Cedar River, Alternative 3 is subparallel to and about 5,000 to 8,000 feet east of this fault. The Echo Lake Substation is about 7,500 feet east of the fault. We did not observe evidence of surface expression of this fault during our field visits.

The Raging River Fault is mostly concealed in the project area. Its trace is interpreted based on rock units exposed north-northwest of Preston, about 1.5 miles northwest of the Echo Lake Substation, and near Steele Creek northeast of Lookout Mountain. Near Steele Creek, the fault juxtaposes undifferentiated Puget Group volcanic rocks to the west against Tiger Mountain Formation rocks to the east. The relative direction of movement is unknown. The southeastern projection of the fault would cross Alternative 3 at the Cedar River. North of the Cedar River, the inferred fault trace diverges from the Alternative 3 alignment until it is about 6,000 feet to the east of the Echo Lake Substation. The Alternative 1 alignment crosses the inferred fault trace about 1,000 feet south of the Raging River. We did not observe evidence of surface expression of this fault during our field visits.

The Piling Creek Fault and its northwestern extension, the Hobart Fault, is inferred through the project area based on exposures 5 to 6 miles northwest and 7 to 8 miles southeast of Selleck. The southeastern extension of the fault has three splays. Assuming the interpreted fault trace is correct, it would cross Alternative 1 about 2,500 feet north of the Cedar River, Alternative 2 at the Cedar River, and Alternative 3 about 1 mile north of the tap with the Schultz-Raver No. 2 line. The fault offset is down to the northeast. We did not observe evidence of surface expression of this fault during our field visits.

3.3 Soils

The soils in the project area have characteristics that are typical of the western Cascades of Washington. The soil characteristic that is most relevant to this study is the erodibility. The Soil Map, Figure 5, is based on soil maps published by the National Resource Conservation Service (NRCS), formerly the Soil Conservation Service (1992). Table 2 lists the soil types that have been mapped in the project area. The soils in the project area formed by a variety of processes, resulting in complex soils with varying thicknesses. The general soil types based on the processes that formed them include:

- Alluvial soil (alluvium) that was deposited directly by streams and rivers. Alluvial soils are restricted to the valley bottoms in the project area.
- Glacial soil that was deposited directly by glaciers (glacial till) and by glacial outwash streams (glaciofluvial deposits). Glacial depositional processes and their consequent deposits are described more fully in Section 3.2, Geology.
- Residual soils (residuum) that formed by weathering in place of the underlying bedrock, alluvium, or glacial deposits. The composition of residual soil depends on the type of underlying geologic parent material and its weathering characteristics; i.e., whether the soil is predominantly fine-grained (silt and clay) or coarse-grained (sand and gravel). In general, residual soil is relatively thin in the project area.
- Colluvial soil (colluvium) has been transported downslope, generally by mass wasting (e.g., landsliding and soil creep). Colluvial soil may cover a layer of residual soil derived from the underlying parent material.
- Volcanic ash from nearby Cascade volcanoes periodically fell over the area and mixed with the other soil types.

The soil units shown on the Soil Map, Figure 5, and described in Table 2 generally can be grouped based on the underlying parent material. The Barneston, Edgewick, Humaquepts, Klaus, Nargar, Ragnar, Skykomish, Sulsavar, and Winston soils generally overlie glacial outwash. Beausite, Chuckanut, Elwell, Norma, Oakes, Rober, Tokul, and Welcome soils typically overlie glacial till. Soils that overlie bedrock units include Beausite, Chuckanut, Gallup, Harnit, Kaleetan, Kankaskat, Littlejohn, Ogarty, Ovall, Pitcher, Playco, Reichel, Stahl, and Welcome. Many of the soil units have some admixture of volcanic ash.

Most of the soils in the project area are more than 5 feet deep, reflecting the depth of underlying glacial and alluvial deposits. Thinner soil is present in areas underlain by bedrock, shown on the Geologic Map, Figure 3. The depth of soil in areas underlain by bedrock ranges from 0 to more than 5 feet, but typically is between 2 and 4 feet. Soils underlain by bedrock are typically thinner on steep slopes underlain by massive, erosion-resistant sandstone and volcanic flow rock. The soil depth can influence surface water runoff and mass wasting potential.

3.4 Regional Seismological Setting

The project site is located in a moderately active tectonic region that has been subjected to numerous earthquakes of low to moderate strength and occasional strong shocks during the brief 170-year historical record in the Pacific Northwest. The tectonics and seismicity of the region are the result of ongoing, oblique, relative northeastward subduction of the Juan de Fuca Plate beneath the North American Plate along the Cascadia Subduction Zone. The convergence of these two plates not only results in east-west compressive strain (Lisowski, 1993), but also results in dextral shear, clockwise rotation, and north-south compression of accreted crustal blocks that form the leading edge of the North American Plate (Wells and others, 1998). The subduction zone extends from Northern California to central Vancouver Island in British Columbia. Western Washington is located in the continental fore-arc of the Cascadia Subduction Zone. The fore-arc consists of accreted sedimentary and volcanic rocks (i.e., Olympic Mountains and Puget Lowland) in front of a landward mountainous, active volcanic arc (Cascade Mountains). The project site is located at the juncture between the accreted rocks and the landward mountainous, volcanic arc.

Within the present understanding of the regional tectonic framework and historical seismicity, three seismogenic sources have been identified (Yelin and others, 1994; Rogers and others, 1997). These include:

- A shallow crustal zone within the North American Plate.
- A deep subcrustal zone (intraslab) in the subducted Juan de Fuca Plate and Gorda plates.
- The Cascadia Subduction Zone, which is the interface between the North American and Juan de Fuca plates beneath the coast.

3.4.1 Shallow Crustal Earthquakes

Shallow crustal earthquakes within the North American Plate beneath the Puget Lowland have historically occurred in a diffuse pattern, typically within 12 miles of the earth's surface. The largest historic event is the 1872 North Cascades earthquake (estimated magnitude 7.0+ in the vicinity of Lake Chelan). However, surface rupture from this large event or other historic shallow crustal earthquakes in the Puget Lowland or Cascade Mountains have not been observed. Two faults with known or suspected Holocene movement (i.e., movement within the last 10,000 years) are the Seattle and South Whidbey Faults. The location of these faults relative to the site is shown on the Vicinity Map, Figure 1. The Seattle Fault is an approximately 1½- to 4-mile wide (north-south) zone consisting of multiple east-west trending strands (Johnson and others, 1999) that extends from near Hood Canal on the west to the Sammamish Plateau on the east. The east end of the southernmost strand (as mapped by Gower, 1985) is approximately 8 miles northwest of the north end of the project. As mapped by Rogers and others (1996), the South Whidbey Fault extends southeast from near Vancouver Island beneath the south end of Whidbey Island and terminates at the foot of the Cascades Mountains on the north side of Mount Si. The northwest-southeast trending South Whidbey Fault is located approximately 8 miles northeast of the project area.

Three northwest-southeast trending faults, the Rattlesnake Mountain, Raging River and Piling Creek Faults, are located within the project area, as shown on the Geologic Map, Figure 3. These faults were inferred based on offsets in Tertiary rock. However, no offset or displacement of overlying Vashon glacial deposits is indicated, which infers that no movement large enough to cause ground rupture has occurred on these faults since deposition of the Vashon deposits (i.e., no ground surface rupture within the last 13,500 to 15,000 years).

3.4.2 Intraslab Earthquakes

Deep subcrustal intraslab earthquakes can occur in the subducted portions of the Juan de Fuca Plate beneath the North American Plate, typically at depths of 25 to 38 miles. Earthquakes within this zone are associated with tensional forces that develop in the subducted plate due to mineralogical and density changes in the plates at depth. Large historic earthquakes from this source zone beneath western Washington include the magnitude (M_s) 7.1 Olympia earthquake of April 13, 1949 and the magnitude (m_b) 6.5 Seattle-Tacoma earthquake of April 29, 1965. Ludwin and others (1991) estimate that the maximum magnitude from this source zone would be about 7.5.

3.4.3 Cascadia Subduction Zone Earthquakes

The third seismogenic zone is near the line of subduction separating the Juan de Fuca Plate from the North American plate, west of the Pacific Northwest coast. The Cascadia Subduction Zone is presently generally quiet, with only scattered and diffuse seismicity. No large subduction earthquakes have occurred in this zone during historic times (170 years). However, geologic evidence suggests that coastal estuaries have experienced rapid subsidence at various times within the last 2,000 years (Atwater, 1987; Atwater, 1997). Atwater postulated that this subsidence resulted from movement along the Cascadia Subduction Zone. Earthquake magnitudes, rupture lengths, and recurrence rates have not yet been well defined for this zone. However, it appears that ruptures of this zone have occurred at irregular intervals that span from about 100 to more than 1,200 years with an average recurrence interval of about 500 years. The last large earthquake is estimated to have occurred about 300 years ago, based on the geologic evidence and historical Japanese tsunami records. Weaver and Shedlock (1997) estimate that rupture of this zone could result in earthquakes with magnitudes on the order of 8½ to 9.

3.4.4 Ground Motions

The USGS has conducted regional probabilistic ground motion studies to estimate potential earthquake ground motions considering the proximity and activity of the various earthquake source zones (Frankel and others, 1996). This study indicates that for ground motions with a 10 percent chance of being exceeded in 50 years (about a 500-year recurrence interval), random crustal earthquakes (i.e., earthquakes occurring on unknown or unidentified faults in the crust) are the greatest contributor to the ground motion hazard. While not as great, intraslab earthquakes also comprise a significant portion of the ground motion hazard. Peak ground accelerations (PGA) on bedrock consistent with a 10 percent chance of exceedance in 50 years are between 0.27g at the north end of the project area and 0.26g at the south end.

3.5 Hydrology

3.5.1 Precipitation

Precipitation patterns in the project area are under the prevailing marine influence of the Pacific Ocean, which produces mild, wet falls and winters, relatively dry summers, and mild temperatures year round. Most of the precipitation falls as rain in the southern lowlands of the project area, while a mixture of rain and snow falls on the upper portions of the northern mountainous area. Annual precipitation in the project area averages between 60 and 80 inches. In general, the annual precipitation amounts increase from west to east. There is a distinct wet season; over 75 percent of the total annual precipitation falls between October and April.

3.5.2 Flooding

The Federal Emergency Management Agency (FEMA) National Flood Insurance Program mapping program, usually conducted in populated areas, identifies areas that have a one percent chance of being flooded in any given year. These areas typically are referred to as the 100-year floodplain. Floodplain mapping by FEMA has not been accomplished in the project area. However, FEMA has mapped the 100-year floodplain along the Cedar River a short distance downstream from the project area. Based on this mapping, it appears that the 100-year floodplain is limited to a narrow area along the active Cedar River channel. The

Raging River, its tributaries, and tributaries to the Cedar River are in moderately incised channels. As such, these streams do not have significant floodplains and flooding generally would not overtop the incised channels. Therefore, towers and roads constructed above the stream channels should not affect or be affected by the stream flood characteristics.

3.5.3 Federal Clean Water Act

The Federal Clean Water Act requires that states protect the water quality of their rivers, streams, lakes, and estuaries. To accomplish this, Section 303(d) of the Clean Water Act requires that each state develop a list of water bodies that do not meet the standards. The 303(d) list is a means of identifying water quality problems. Once a stream is placed on the list, the Clean Water Act requires that the state develop a plan to reduce pollution. The states must submit the "water quality limited" list to the Environmental Protection Agency (EPA) every two years. In Washington State, the Department of Ecology (Ecology) is responsible for developing the standards that protect beneficial uses such as drinking water, cold water for fish, industrial water supply, and recreational and agricultural uses. Ecology is also responsible for compiling the 303(d) list and submitting it to EPA for approval. Parameters that Ecology typically monitors include bacteria, pH, dissolved oxygen, temperature, total dissolved gas, certain toxic and carcinogenic compounds, habitat and flow modification, fecal coliform, turbidity, and aquatic weeds or algae that affect aquatic life.

The proposed transmission line routes cross the following water bodies in the project area: Cedar River, Raging River, Rock Creek, Taylor Creek, Steele Creek, and Canyon Creek. At this time, none of these water bodies in the project area are listed on the Washington State 303(d) water quality limited water bodies list. Therefore, no water quality limiting factors are identified in the project areas that would be affected by construction, operation, and maintenance of the proposed new transmission line. The Cedar River is listed for fecal coliform west of the project area. In our opinion, the proposed action should not increase fecal coliform upstream from the listed portion of the Cedar River.

The project area includes portions of the City of Seattle Cedar River Watershed. Both water quality and quantity are important components of the Cedar River Watershed's ability to provide a clean and reliable drinking water supply. The existing water quality of the Cedar River is high. Degradation in water quality could affect the City of Seattle's ability to meet federal regulations for the treatment of surface water and potentially increase public health risks.

3.5.4 Groundwater

No sole-source aquifers designated or proposed by the US Environmental Protection Agency (EPA) exist in the project area; however, domestic wells are located within the project area. The principal groundwater aquifers are in glacial outwash deposits in the southern lowland area. These aquifers are locally developed for domestic and some farm consumption in the communities of Selleck and Kangley. In the northern mountainous area, the community of

Halmar Gates, near the end of Kerriston Road, likely uses groundwater for domestic consumption. Wells in this area would produce groundwater from the underlying bedrock.

3.6 Wind

Wind can affect the stability of transmission lines and towers. Wind can also affect forests adjacent to the cleared ROW. High winds can cause windthrow, which affects timber resources and poses a potential hazard to transmission lines.

During our helicopter overflight and field visits we observed an area of windthrow along a timber harvest buffer leave area along Canyon Creek. The area adjacent to the leave areas had been recently clearcut harvested. Canyon Creek is a tributary to the Raging River and is located about one mile south of the Echo Lake Substation along Alternative 3. The windthrow indicated that strong southerly winds occur through the Raging River Valley.

Chapter 4 Environmental Consequences

This chapter discusses the environmental consequences of the proposed alternatives on the resources described in the previous chapter. The chapter is divided into three general areas of resources: Geology and Soils, Seismic, and Hydrology and Climate. Each of these sections first defines impact levels for or each resource, generally using a scale with impact levels of high, moderate, low, and no impact. Next, is a discussion of general impacts that are common to all of the proposed alternatives and a general background regarding impacts to each resource. Following the general discussion of impacts, the impacts that could occur along each alternative are described in detail, together with a description of mitigation measures that likely would be required, cumulative impacts, and unavoidable effects, irreversible or irretrievable commitments of resources.

4.1 Geology and Soil

4.1.1 Geology and Soil Impact Levels

Direct impacts from the project would be caused by new access road construction, improvements to existing access roads, ROW clearing, and site preparation for construction of structures. During construction, these activities would disturb the soil surface, which could lead to an increase in soil erosion, runoff, and sedimentation in nearby water bodies. Long term maintenance, and especially ROW maintenance, could impair soil productivity and remove land from timber and farm production or other uses.

The following sections describe potential environmental consequences from construction, operation and maintenance of the proposed BPA Kangley-Echo Lake transmission project in hazard areas identified along each of the proposed alternative routes. Of the identified hazards, landslides and soil erosion resulting from construction, operation and maintenance of the project are most likely to have impacts on environmental resources (fish and water).

Landslide Impact Levels – Landslide impacts could occur if construction or maintenance of the proposed project triggers a landslide, or if a landslide is triggered by natural factors, such as a large storm, combined with factors related to the line.

Deep-seated landsliding has the greatest potential to impact a transmission alignment; however the potential for a deep-seated landslide is relatively small. Only one deep-seated landslide was identified along the alternative routes on the south flank of Brew Hill along Alternative 1 (Sheet 2 of Figure 5). This landslide feature is apparently ancient and does not appear to be active. Portions of the alternative routes were assigned a high, moderate, low, or no deep-seated landslide hazard category as follows:

- High deep-seated landslide hazard was assigned to areas with active deep-seated landsliding, or where numerous ancient deep-seated landslides were identified adjacent to the alignment. No high, deep-seated landslide hazard areas were identified in the project area.

- Moderate deep-seated landslide hazard was assigned to areas where isolated ancient deep-seated landslides were identified near the alignment. The ancient landslide on the south flank of Brew Hill is the only moderate deep-seated landslide hazard in the project area.

- Low deep-seated landslide hazard was assigned to areas that had similar characteristics as the moderate hazard landslide areas (i.e., slope, dip of bedded rocks, geologic contacts, etc.), but no landslides were identified nearby.

- No deep-seated landslide hazard was assigned to areas where deep-seated landslides were not identified and the geologic conditions do not appear conducive to deep-seated landsliding. Most of the project area falls within this category.

No shallow landslides were identified along the alignment, either on the aerial photographs or during the field reconnaissance. Shallow landslide hazards were assigned to a high, moderate, low or no shallow landslide hazard category as follows:

- High shallow landslide hazard was assigned to those sections of the alternative routes on slopes that exceed 65 percent and that are in the vicinity of mapped or observed areas of concentrated past shallow landslide movement. No high shallow landslide hazard areas were identified in the project area.

- Moderate shallow landslide hazard was assigned to those sections of the alternative routes on slopes that exceed 65 percent and are in the vicinity of isolated shallow landslides. No moderate shallow landslide hazard areas were identified in the project area.

- Low shallow landslide hazard was assigned to those sections of the alternative routes where no existing shallow landslides were identified, but where converging slopes exceed 65 percent or where slopes steeper that 40 percent are present in confined drainages.

- No shallow landslide hazard was assigned to all remaining sections of the alternative routes not identified as high, moderate, or low.

Soil Erosion Impact Levels – Potential soil-related impacts in the project area were evaluated and mapped using the Soil Survey of Snoqualmie Pass Area, Parts of King and Pierce Counties, Washington (USDA, 1992). The soil survey includes soil maps and descriptions of soil composition and structure. They also describe the soil engineering characteristics, such as Unified Soil Classification (USC), grain size, plasticity, erosion potential and organic content.

Surface erosion of soil can occur as a result of wind and downslope movement, such as creep or ravel; however, soil erosion is most often associated with flowing water. Soils that are most susceptible to surface erosion by water have no or minor cohesion (as a result of a low percentage of clay minerals) or have a low percentage of gravel-size particles (which would otherwise armor the soil surface). Other factors that lead to high rates of soil erosion are disturbance, absence of vegetative cover, concentrated water and steep slopes.

Table 7 of the Soil Survey of Snoqualmie Pass Area (USDA, 1992) defines soil erosion hazards of slight, moderate and severe, which indicate the risk of loss of soil in *well-managed woodland* (italics added for emphasis). These ratings are summarized below. Table 2 of this report lists these soil hazard ratings, as defined by the USDA (1992) for the soils that occur in the project area.

- High erosion impact was assigned to those sections of the routes that cross soil units identified as severe erosion hazards. These soils may require intensive management or special equipment and methods to prevent excessive loss of soil. The Tokul gravelly loam on slopes steeper than 45 percent is the only soil with a severe erosion hazard that would be crossed by the proposed Alternative routes (Alternatives 1 and 3).

- Moderate erosion impact was assigned to those sections of the alternative routes that cross soil units identified as moderate erosion hazards. These soils may require erosion control measures during logging and road construction to prevent excessive loss of soil.

- Low erosion impact was assigned to those sections of the alternative routes that cross soils identified as slight erosion hazards. Loss from these soils during construction is expected to be small.

- No erosion impact would occur only in soils that are not disturbed during the construction and maintenance of the proposed project.

Excavation Difficulty Impact Levels – The degree of excavation difficulty for road and transmission line tower construction is based on expected depths of soil and bedrock, and the expected strengths of bedrock. An average excavation depth of 15 feet was assumed for tower footings. Similar excavation depths can be assumed for road construction (i.e., cut slopes). For assigning excavation difficulty, rock is defined as material that requires blasting or use of hydraulic breakers for excavation. Material that can be excavated entirely with conventional earth-moving equipment, including rippers, is considered to be soil.

Although excavation difficulty does not represent a hazard to the environment, the type of excavation required does affect the construction methods used, which in turn can affect the environment. Excavation difficulty ratings of high, moderate, and low were assigned based on the expected geologic unit and the following criteria:

- High excavation difficulty was assigned to areas that are underlain by bedrock, which includes the sedimentary Tukwila, Raging River, and Tiger Mountain Formations, and intrusive, volcanic and volcanicalstic rocks. Much of the near-surface rock can probably be ripped and/or excavated by machine. However, deeper excavations or excavations in harder or more massive bedrock may require blasting and/or hydraulic breaking.

- Moderate excavation difficulty was assigned to areas that are underlain by glacial till and other glacially-overridden soils (advance outwash and some ice-contact deposits). In general, these soil types can be excavated with conventional excavation equipment. However, excavation may require large earthwork equipment and rates may be slow. Local boulder deposits and unanticipated bedrock outcrops may require hydraulic breaking and/or blasting to complete excavations.

- Low excavation difficulty was assigned to the remaining sections of the alternative routes that were not assigned a moderate or high hazard. While the potential for rock excavation is small, there is the possibility of encountering large boulders, rockslide blocks, or other unidentified, hard or massive rock.

Settlement Impact Levels – Settlement occurs when soft or loose soil consolidates or densifies under loads. Loads can include fill placed for a road or foundations of a transmission line tower or other structure. Wet, fine-grained soil or soil that contains abundant organic material usually have the greatest potential for settlement. These types of soil typically occur in alluvial environments, such as river valleys, bays, and estuaries. Poorly compacted fills and fills with organic material are also susceptible to settlement.

Settlement impact levels were assigned as follows:

- High settlement impact was assigned to areas where structures might be built on swampy areas and recent alluvium.

- No settlement impact was assigned to all other areas.

4.1.2 Geology and Soil General Impacts

Landslides – Poor practices in design and construction of access roads and clearing of wide swaths of forest on slopes that are susceptible to landsliding may cause an increase in the rate and/or size of landslides. The factors that affect landsliding, other than natural factors, include poor road construction practices, improperly placed fills, poorly-designed cut slopes, poor drainage, and, to a lesser degree, logging. Fills placed for roads on slopes steeper than about 60 percent, poorly compacted fills, poor quality fill material, and poorly prepared subgrades create conditions that are particularly susceptible to landsliding. A steep cut that is made in poorly drained soil or in loose, granular soil could initiate a landslide. Landslides are commonly triggered by poor road drainage resulting from undersized culverts, culverts that are spaced too far apart, blocked culverts, or from poorly maintained roads and ditches. Logging dense coniferous forests on steep slopes could increase the potential for landslides to occur as a result of reduced soil strength. Reduced soil strengths can occur from increased soil water that results from the loss of interception and evapotranspiration of precipitation, and to a lesser extent, the loss of root strength.

Most shallow landslides would probably not significantly impact the transmission line towers. However, they could increase the rate at which sediment and debris is delivered to streams, reduce the amount of land for timber production, and cause temporary access road closures.

Shallow landslides can liquefy after moving a short distance and become debris flows. Debris flows typically move rapidly down the slope, eroding and accumulating additional material until they reach a low gradient slope or the valley bottom.

Deep-seated landslides could deposit large quantities of debris into streams, which, in turn, may degrade fish habitat and water quality. Because of their potential size, deep-seated landslides can have a significant impact on existing public and private roads and properties that are downslope of the landslide. Movement of a deep-seated landslide across the transmission line ROW could displace or topple the towers and potentially snap or short the conductors. Small, chronic movements of the landslide mass would require frequent maintenance. Deep-seated landslides can be initiated by poorly-designed road cuts, excessive fills, or discharge of excessive concentrated drainage. Inactive, deep-seated landslides can be reactivated by excavating cuts at the toes, placing fills at the tops, or by discharging excessive concentrated water onto the slide body.

Soil Erosion – Construction of roads, ROW clearing, and site preparation for transmission line tower footings and the substation facilities will expose and disturb soil, increasing the potential for surface erosion of soil from its pre-disturbed condition. The eroded soil could enter streams and impact fish habitat and water quality. Sources for increased sediment include unprotected cut and fill slopes, road surfaces, and spoil piles. Most impacts would likely be short term. Once the cuts and fills adjacent to roads and the areas cleared for tower construction revegetate, the road surfaces are graveled or naturally become armored, and the substation construction is complete, erosion rates should reduce substantially and not significantly affect nearby streams and other water bodies. Long-term impacts should be small unless efforts to revegetate and control erosion and runoff are unsuccessful and/or not maintained.

Excavation Difficulty – Based on expected soil depths and rock strengths, excavation for most of the roads and footings can be accomplished with conventional earthwork equipment. However, some sections of the access roads may require blasting to remove massive and/or hard bedrock, while some tower foundations may require drilled rock anchors. Blasting of the bedrock could temporarily disturb residents living nearby and wildlife. Excavations in soil can generate spoils and create slopes that typically are more susceptible to erosion than bedrock spoils and slopes.

Settlement Hazard – Transmission line towers founded improperly on soil that is settlement-prone could settle differentially to the point that they would not function as designed. Settlement induced by constructing the transmission line towers could have indirect environmental impacts as a result of additional maintenance work and possible construction of new foundations.

4.1.3 Alternative 1 Geology and Soils

4.1.3.1 Alternative 1 Impacts

Alternative 1 parallels the existing Raver-Echo Lake transmission line, so that most of the road system is already in place. As a result, in most cases, only short spur roads to the actual tower sites from the existing roads would be needed. Small intermittent streams may be crossed by these spur roads and culverts could be required for passage of storm water.

Landslides – One area of moderate deep-seated landslide hazard was identified along an approximate 3,000-foot long portion of Alternative 1 (Table 3). This area is the ancient deep-seated landslide that has been mapped in Section 35 on the southeast flank of Brew Hill and across which the existing transmission line traverses (Figures 3 and 5). However, observations made during the field evaluation did not indicate unstable slopes or recent movement in this mapped landslide area. No high or low deep-seated landslide hazard areas were identified along Alternative 1.

High or moderate shallow landslide hazard areas were not identified along Alternative 1. Low shallow landslide hazard areas (Table 3 and Figure 5), totaling about 2,500 feet in length, were identified at:

- The north and south slopes above the Cedar River in Section 14.
- The stream crossings on the north and south sides of Brew Hill, Sections 26 and 35, respectively.
- The north and south slopes above the Raging River, Section 14.

Road construction across the mapped deep-seated landslide feature could reactivate a portion of this landslide. Poor design and road construction practices, excessive road drainage or poor maintenance of roads in the areas of shallow landslide hazard could initiate a landslide that could deliver sediment to fish-bearing waters. Because a road system already exists along most of Alternative 1 and only short spur roads should be required, the potential for project-related, road-initiated landslides should be small.

Existing design standards for the proposed transmission line alignment call for a clearing width of 150 feet. This would require the clearing of approximately 165 acres of second- and third-growth timberland (Table 3). Because Alternative 1 parallels an existing cleared alignment, the clearing width could potentially be reduced. Additional clearing would also be required for access road construction. However, because extensive new road would not be required for this alternative, the amount of clearing for roads will be relatively small. Landslides could be triggered in the areas identified as shallow landslide hazard due to hydrologic change as a result of cleared transmission line corridors. However, evidence of past shallow landsliding was not observed along the existing transmission line corridor in the areas of shallow landslide hazard.

Soil Erosion – The total length of the Alternative 1 route is approximately 9 miles. Of this, about 0.3 miles (3%) cross soil designated as a severe erosion hazard, 1.4 miles (15%) cross soil designated as a moderate erosion hazard, and the remaining 82% of the route crosses soil designated as a slight erosion hazard (Table 3 and Figure 5). The severe erosion hazard occurs on the slopes above the Raging River.

Poor design and construction or poor maintenance activities on the severe and moderate hazard soil erosion areas could increase soil erosion and delivery of sediment to fish-bearing waters. In most cases, only short spur roads from the existing roads to the actual tower sites would be needed. In addition, the need for construction of additional culverts and bridges, and the resulting potential impacts to water bodies, would be significantly reduced compared to the number of similar drainage structures required for a new road system. Culverts may be required where the short spur roads cross small, intermittent streams.

The increased amount of surface water runoff resulting from the lengthened road prism and additional cleared slopes could potentially cause an increase in peak flows. Increased surface runoff and peak flows can cause additional erosion at road cuts and fills, along drainage ditches, below culvert outfalls, and in stream channels. However, the anticipated increase is expected to be small relative to existing conditions.

Excavation Difficulty – We did not observe rock outcrop along the Alternative 1 alignment, and soil units that are indicative of shallow bedrock were not mapped along Alternative 1 (Figure 5). Therefore, we do not anticipate that shallow, hard bedrock will be present that could cause difficult excavation conditions.

Boulder and gravel recessional outwash deposits are present south of the Cedar River along the alternative route. In addition, isolated glacial erratic boulders could be present in glacial till deposits; i.e., at almost all locations along the proposed alignment. Large boulders might require blasting to excavate for tower foundations, because, in most cases, rock anchors placed in large boulders would not form a suitable foundation.

Typically, tower foundations are placed to the same depth, whether in soft rock or soil, to provide sufficient resistance to uplift. Therefore, the amount of spoils generated should be similar for soft rock or soil excavation. However, the amount of material produced that is erodible by surface processes should be less for rock excavation than for soil excavation. Unless adequate mitigation measures are implemented, erosion of the spoils could deliver sediment to nearby water bodies.

Hard rock excavation could require the use of blasting and/or hydraulic breakers. These methods would generate more noise and dust than using excavation equipment only.

Settlement Hazard - No settlement hazards were identified along Alternate 1.

4.1.3.2 Mitigation

Where possible, hazard avoidance is the most effective method to mitigate impacts from or to the project facilities. During preliminary and final route selection (including tower and road locations), avoidance would be the primary means of mitigation. For those areas where potential natural hazards are present and unavoidable, measures to mitigate impacts that could result from the construction, operation and maintenance of the project can be implemented. Site-specific mitigation measures would be developed following selection of a specific route.

Roads - Most landslide and soil erosion impacts probably would be the result of road construction and use. Therefore, the most direct way to reduce these impacts is to reduce the amount of new road construction. Access roads would be required to clear the alignment ROW and to construct and maintain each transmission line tower. Typical transmission line tower spacing will be about 1,100 to 1,200 feet, except where longer spans are required to cross streams such as the Raging River and the Cedar River. Modern logging techniques utilizing cable systems also allow more ground to be accessed with fewer roads.

Once a specific route is selected, the proposed access road alignments should be evaluated in the field to identify site-specific hazards. Engineering analyses should be conducted and road stabilization measures designed and constructed where required. An Erosion and Sediment Control Plan (ESCP) that incorporates Best Management Practices, (BMPs) would be developed and implemented for specific areas, such as road crossings at streams, to minimize delivery of sediment to sensitive resources. To reduce the potential for road failures, roads could be located along ridge tops wherever feasible. Roads along or near ridge tops are more stable because deep side cuts across slopes and side hill fills generally are not required, and stormwater runoff is typically less intense. Seasonal restrictions can be placed on road construction operations to reduce the potential of erosive events and impacts to wildlife.

Erosion of fine sediment from road surfaces can contribute sediment to a drainage system. To reduce surface erosion, those roads that will be actively used could be surfaced with sound crushed rock and maintained on a regular basis. Maintenance can include grading, ditch and culvert cleaning, cut slope revegetation, and repair of identified potential failure sites. Roads that will not be used following construction should be restored to approximately pre-existing conditions or stabilized with vegetation and drainage measures (e.g., water bars, removing culverts, and sidecast fill removal).

Right-of-Way Clearing - Under local regulations, wetlands and streams are required to have protective buffers. Wetlands, streams, and associated buffers would be left undisturbed where practical.

Disturbance of the soil cover during logging should be low if using cable or appropriate ground-based logging methods. A low ground cover of vegetation consisting of shrubs and grasses would remain following logging and the cleared area would not be burned. Over the years, this vegetation will grow to a taller, denser condition. Consequently, the benefits of vegetation, including root strength, soil cover, interception and evapotranspiration of precipitation, will remain.

Other Mitigation Measures -

- Properly space and size culverts; use crossdrains, water bars, rolling dips, and armoring of ditches, and drain inlets and outlets.

- Improve all existing culverts and stream crossings that pose a risk to riparian, wetland, or aquatic habitat to accommodate at least a 50-year flood and associated bedload and debris.

- Coordinate all culvert installations with the appropriate federal, state and local agencies.

- Preserve existing vegetation where possible and stabilize disturbed portions of the site. Implement stabilization measures as soon as practicable where construction activities have temporarily or permanently ceased.

- Promptly seed disturbed sites with an approved herbaceous seed mixture suited to the site.

- Use vegetative buffers and sediment barriers to prevent sediment from moving off-site and into water bodies.

- Design and construct fords and bridges to minimize bank erosion. Identify specific locations and measures when road and line designs are finalized.

- Schedule construction and maintenance operations during periods when precipitation and runoff potential is at a minimum to reduce the risk of erosion, sedimentation, and soil compaction.

- Design facilities to meet regional seismic criteria.

- Use full-bench road construction and end hauling of excess material on slopes exceeding 60 percent, if needed to stabilize road prisms. Prior to construction, locate suitable waste areas for depositing and stabilizing excess material.

- Construct access roads consistent with the standards and guidelines of the Washington State Department of Natural Resources and other applicable guidelines.

- Avoid riparian areas, drainage ways, and other water bodies. Where these areas cannot be avoided, apply sediment reduction practices to prevent degradation of riparian or stream quality. Consider using riparian plantings where needed to restore streamside vegetation and insure streambank stability.

- Restrict road construction to the minimum needed and obliterate non-essential existing roads and temporary construction access roads.

- Avoid discharge of solid materials, including building materials, into waters of the United States unless authorized by a Section 404 permit of the Clean Water Act. Reduce off-site tracking of sediment and the generation of dust. Leave vegetative buffers along stream courses to minimize erosion and bank instability.

- Prepare a Stormwater Pollution Prevention Plan (SWPPP), as required under the National Pollution Discharge Elimination System General Permit.

- Design the project to comply with local regulations and state and federal water quality programs to prevent degradation of aquifer quality and avoid jeopardizing their usability as a drinking water source.

4.1.3.3 Cumulative Impacts

Current and future forest management practices in the watersheds that Alternative 1 crosses might increase peak flows and introduce sediment into streams. Increased sediment and peak flows in streams is expected from construction and operation of the line alternatives in addition to forest management activities. The volume of peak flow and the amount of sediment entering streams would depend on site-specific conditions. Mitigation measures proposed for construction of the line and those required for logging-related activities would reduce the chance of large amounts of sediment entering streams. Although minor, localized increases in erosion, runoff, and sedimentation are expected from construction and maintenance, these increases would have a low impact on the area's soil resources and water quality, and should not impair the current beneficial use of water bodies.

4.1.3.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Additional land clearing and road construction, with their attendant short- and long-term impacts discussed above, are unavoidable in order to complete the proposed project. If the project is abandoned, the disturbed ground could be restored and, over a period of years, revegetated to pre-existing conditions. Resources, such as fuel oil, lubricants and metals, will be consumed during construction and maintenance of the project. Aggregate materials will be used in road and tower foundation construction, and for road surfacing maintenance. These materials will require mining and transportation.

4.1.4 Alternative 2 Geology and Soils

4.1.4.1 Alternative 2 Impacts

The Alternative 2 alignment differs from the Alternative 1 alignment along the last segment at the south end where it crosses the Cedar River. From the tap point of the Schultz-Raver No. 2 line north to Anacortes Road (Cedar River Watershed road No. 80), the route crosses a relatively recent clearcut. From Anacortes Road north to the Cedar River, tower locations likely would be within 200 to 300 feet of Pole Line Road (Cedar River Watershed Road No. 50), Road No. 54 or the Railroad ROW (Cedar River Watershed Road No. 9). North of the Cedar River, Rocky Road (Cedar River Watershed Road No. 40), Road No. 10.4a, Green Valley Road (Cedar River Watershed Road No. 31) and Road No. 32 provide access to within about 500 feet of most likely tower locations. One tower location may be about 800 to 1,000 feet from an existing road. These spur roads may cross small intermittent streams that could require culverts.

Landslides – No shallow or deep-seated landslide hazard areas were identified along the Alternative 2 alignment, except where Alternative 2 coincides with Alternative 1 (see Section 4.1.3.1). Low shallow landslide hazard areas are slightly less widespread than Alternative 1 (3% of alignment length instead of 5% for Alternative 1) because of the alternate crossing of the Cedar River (Table 3 and Figure 5).

Numerous roads exist along Alternative 2 and along the portion of Alternative 1 that coincides with Alternative 2. As a result, only relatively minor road building would be required, generally consisting of short spur roads. The Alternative 2 segment across the Cedar River valley typically crosses gentle to moderately sloped ground, such that new roads, where required, should not require large cuts or fills.

Alternative 2 is also approximately 9 miles long. Assuming a 150-foot wide transmission line corridor, approximately 165 acres of second and third-growth timberland would need to be cleared (Table 3).

Impacts to slope stability from Alternative 2 land clearing and road construction will be similar to those of Alternative 1 (see Section 4.1.3.1)

Soil Erosion – About 0.3 miles (3%) of Alternative 2 cross soil designated as a severe erosion hazard, 1.4 miles (15%) cross soil designated as a moderate erosion hazard, and the remaining 82% crosses soil designated as a slight erosion hazard (Table 3 and Figure 5). The severe erosion hazard occurs on the slopes above the Raging River.

Because of the lack of streams across the route, the moderate- to low-sloped ground, and the number of existing roads adjacent to Alternative 2, new tower construction access roads will generally not require stream crossings with their attendant potential erosion and sedimentation impacts. Culverts may be required where the short spur roads cross smaller, intermittent streams.

Impacts of project construction and operation on soil erosion and sediment delivery will be similar to those impacts described for Alternative 1 (see Section 4.1.3.1).

Excavation Difficulty – We did not observe rock outcrop along the Alternative 2 alignment. Soil units that are indicative of shallow bedrock were not mapped along Alternative 1 (Figure 5). Excavation difficulty, and its associated impacts, should be similar to Alternative 1 (see Section 4.1.3.1).

Settlement Hazard - No settlement hazards were identified along Alternate 2.

4.1.4.2 Mitigation

Refer to measures under Alternative 1, see Section 4.1.3.2.

4.1.4.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.1.3.3.

4.1.4.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.1.3.4).

4.1.5 Alternative 3 Geology and Soils

4.1.5.1 Alternative 3 Impacts

From the tap point of the Schultz-Raver No. 2 line north to Anacortes Road, Alternative 3 crosses the same clearcut as described for Alternative 2. From Anacortes Road north to Pole Line Road (Cedar River Watershed Road No. 50), the route and likely tower locations are within about 300 feet of Bonus Creek Road (Cedar River Watershed Road No. 53). The route would closely follow Pole Line Road along a gentle terrace northwest for 2 miles where it then would turn northeast and cross the Cedar River. New roads to this point would be limited to short spur roads from existing roads to each tower location and should not require large cuts of fills.

From the Cedar River, the route climbs about 900 feet over a horizontal distance of about 2,500 feet to a ridge, and then crosses Steele Creek. The tower locations on the slope would be adjacent to the Cedar Falls Road (Cedar River Watershed road No. 10), Road 20 and Road 21. Spur roads would be required for the towers on the ridge above and west of Steele Creek. These roads might be several thousand feet long, depending on the actual tower locations. Road cut and fills similar to those required for road No. 21 could be required where the spur roads cross slopes of 40 percent or steeper.

North of the Cedar River Watershed, Alternative 3 crosses gentle to moderate slopes over private timberland. The area has an existing, relatively dense road network used for logging activities. South of the Raging River (in the southwest ¼ of Section 30) most of the proposed route is within about 1,000 to 2,000 feet of existing roads. North of the Raging River, the proposed Alternative 3 route is within about 1,000 feet of existing roads.

Because of the existing road network, additional culverts and bridges should not be needed across the larger streams. However, a crossing will probably be required across a relatively large stream in Section 31 to access the alignment south of the Raging River.

Landslides – An area of low deep-seated landslide hazard north of the Cedar River and on the east bank of Steele Creek (Figure 5) was designated because conditions are similar to the mapped moderate landslide hazard area (i.e., similar bedrock with an adverse dip into the Cedar River Valley). No high or moderate hazard deep-seated landslide areas were identified along Alternative 3.

No high or moderate shallow landslide hazard areas were identified along Alternative 3. Low hazard shallow landslide hazard areas (Table 3 and Figure 5), totaling about 2,800 feet in length, were identified along the Alternative 3 alignment at:

- The stream crossings of Canyon Creek and the adjacent creek to the south, Section 13.

- The north and south slopes above the Raging River, Section 30.

- The east slopes above Steele Creek, Section 6.

- The east and west slopes above Taylor Creek, Section 13.

Alternative 3 is approximately 10.4 miles long. Assuming a 150-foot wide transmission line corridor, approximately 190 acres of second and third-growth timberland would need to be cleared (Table 3).

The type of impacts to slope stability from Alternative 3 land clearing and road construction will be similar to those of Alternative 1 (see Section 4.1.3.1). The greatest potential landslide impacts would occur on the steep slopes above the larger drainages listed as shallow landslide impacts above. A shallow landslide on one of these slopes could deliver sediment directly to a fish-bearing water body.

Soil Erosion – About 0.2 miles (2%) of Alternative 3 cross soil designated as a severe erosion hazard, 2.1 miles (20%) cross soil designated as a moderate erosion hazard, and the remaining 78% of the route crosses soil designated as a slight erosion hazard (Table 3 and Figure 5). The severe erosion hazard occurs on the slopes above the Raging River and Canyon Creek.

Although impacts from project construction and operation on soil erosion and sediment delivery would be similar to those impacts described for Alternative 1 (see Section 4.1.3.1), the relative amount of potential impacts will be greater because Alternative 3 will require more of new access road. More stream crossings with their attendant potential erosion and sedimentation impacts would be required with this alternative.

Excavation Difficulty – Some rock outcroppings are present along the Alternative 3 alignment. These outcrops are located on the slope north of the Cedar River and east of Steele Creek, and along the east flank of Rattlesnake Mountain between the northern Cedar River Watershed boundary and Canyon Creek. Much of the east flank of Rattlesnake Mountain is covered with a thin mantle of glacial till that obscures the underlying bedrock (refer to the Geologic Map, Figure 3). Typically, these rock outcrops are deeply weathered and can be excavated with conventional equipment to depths of 5 to 10 feet. Deeper excavations might require blasting or the use of a hydraulic impact hammer.

Soil units along Alternative 3 that typically form a relatively thin cover over hard bedrock include the following:

- Pitcher sandy loam (soil unit , which develops over andesite, is located on the slope north of the Cedar River, described above. The underlying rock is undifferentiated Puget Group volcanics.

- Ogarty gravelly loam, which commonly overlies andesite and volcanic breccia, is present west of the proposed alignment about 2 miles southeast of the Echo Lake Substation. Several borrow pits were made in the Tukwila Formation bedrock, which commonly underlies the Ogarty gravelly loam, to a depth of 20 feet or more. It appeared that the excavations were made without blasting.

Settlement Hazard – An area of alluvium is mapped in the southeast corner of Section 13 on a terrace near the mouth of Taylor Creek. This area has been identified as a potential settlement hazard. No other settlement hazards were identified along Alternative 3. General settlement impacts are discussed in Section 4.1.2. Impacts to the environment resulting from settlement would include potential ground disturbance during repair and maintenance operations.

4.1.5.2 Mitigation

In general mitigation required for this alternative will be similar to Alternative 1 (see Section 4.1.3.2). However, because the length of this alternative is greater than the other alternatives, the mitigation measures may be greater. The potential excavation of hard rock might require some blasting. The timing of blasting may need to be coordinated to avoid conflicts with residents and wildlife. Subsurface explorations should be conducted to evaluate subsurface materials and their susceptibility for settlement under the expected loads. Foundation engineering measures, such as piles or overexcavation, could be employed to reduce the amount of settlement.

4.1.5.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.1.3.3.

4.1.5.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.1.3.4).

4.1.6 Alternative 4A Geology and Soils

4.1.6.1 Alternative 4A Impacts

From the point Alternative 4A diverges from the Alternative 2 alignment to the southern Cedar River Watershed boundary, the likely tower locations would be within 300 feet of Anacortes Road. Depending on the actual tower locations, Road 80.2 could be used to provide access to one tower. North of the Cedar River Watershed boundary, one tower location would be close to Pole Line Road, and a second would be within 300 feet of Road No. 54. Therefore, new roads would be limited to short spur roads from existing roads to each tower location and should not require large cuts or fills. Other than culverts that may be needed along the portion of Alternative 1 that coincides with Alternative 4A, no additional bridges or culverts to cross streams should be required along this alternative.

Landslides – No shallow or deep-seated landslide hazard areas were identified along the Alternative 4A alignment, except where this alternative coincides with Alternative 1 (see Section 4.1.3.1). The landslide hazards along Alternative 4A are similar to those along Alternative 1 (Table 3 and Figure 5).

Relatively minor road building should be required because the trunk road system is mostly in place. New road would consist primarily of short spur roads. Alternative 4A is approximately 10 miles long. Assuming a 150-foot wide transmission line corridor, approximately 175 acres of second and third-growth timberland would need to be cleared (Table 3). Impacts to slope stability from Alternative 4A land clearing and road construction should be similar to those of Alternative 1 (see Section 4.1.3.1)

Soil Erosion – About 0.3 miles (3%) of Alternative 4A cross soil designated as a severe erosion hazard, 1.5 miles (15%) cross soil designated as a moderate erosion hazard, and the remaining 82% of the route crosses soil designated as a slight erosion hazard (Table 3 and Figure 5). Severe erosion hazard is present on the slopes above the Raging River.

Because of the number of existing roads adjacent to Alternative 4A, new access roads will generally not require additional stream crossings with their attendant potential erosion and sedimentation impacts. Culverts may be required where the short spur roads cross smaller, intermittent streams. Impacts of project construction and operation on soil erosion and sediment delivery will be similar to those impacts described for Alternative 1 (see Section 4.1.3.1).

Excavation Difficulty – We did not observe rock outcrop along the Alternative 4A alignment, and soil units that are indicative of shallow bedrock are not mapped along Alternative 4A (Figure 5). Therefore, we anticipate that excavation difficulty, and its associated impacts, will be similar to Alternative 1 (see Section 4.1.3.1).

Settlement Hazard - No settlement hazards were identified along Alternative 4A.

4.1.6.2 Mitigation

Refer to measures under Alternative 1, see Section 4.1.3.2.

4.1.6.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.1.3.3.

4.1.6.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.1.3.4).

4.1.7 Alternative 4B Geology and Soils

4.1.7.1 Alternative 4B Geology and Soils Impacts

The segment of this route that connects portions of Alternative 2 to Alternative 1 follows Pole Line Road. Tower locations would be within 100 feet or less of the road. New roads would be limited to short spur roads from Pole Line Road to each tower location and should not require large cuts or fills.

Other than the additional culverts that may be needed along the portion of Alternative 1 that coincides with Alternative 4B, no additional bridges or culverts would be required along this alternative.

Landslides – No shallow or deep-seated landslide hazard areas were identified along the Alternative 4B alignment, except where this alternative coincides with Alternative 1 (see Section 4.1.3.1). The landslide hazards along Alternative 4B are similar to those along Alternative 1 (Table 3 and Figure 5).

Relatively minor road building should be required because the trunk road system is mostly in place. New road would consist primarily of short spur roads. Alternative 4B is approximately 10 miles long. Assuming a 150-foot wide transmission line corridor, approximately 185 acres of second and third-growth timberland would need to be cleared (Table 3). Impacts to slope stability from Alternative 4B land clearing and road construction should be similar to those of Alternative 1 (see Section 4.1.3.1)

Soil Erosion – About 0.3 miles (3%) of Alternative 4B cross soil designated as a severe erosion hazard, 1.5 miles (15%) cross soil designated as a moderate erosion hazard, and the remaining 82% of the route crosses soil designated as a slight erosion hazard (Table 3 and Figure 5). Severe erosion hazard occurs on the slopes above the Raging River.

Because of the number of existing roads adjacent to Alternative 4B, new tower construction access roads would generally not require additional stream crossings with their attendant potential erosion and sedimentation impacts. Culverts may be required where the short spur roads cross smaller, intermittent streams. Impacts of project construction and operation on soil erosion and sediment delivery will be similar to those impacts described for Alternative 1 (see Section 4.1.3.1).

Excavation Difficulty – We did not observe rock outcrop along the Alternative 4B alignment, and soil units that are indicative of shallow bedrock are not mapped along Alternative 4B (Figure 5). We anticipate that excavation difficulty, and its associated impacts, will be similar to Alternative 1 (see Section 4.1.3.1).

Settlement Hazard - No settlement hazards were identified along Alternative 4B.

4.1.7.2 Mitigation

Refer to measures under Alternative 1, see Section 4.1.3.2.

4.1.7.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.1.3.3.

4.1.7.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.1.3.4).

4.2 Seismic

4.2.1 Seismic Impact Levels

Liquefaction Impact Levels – Liquefaction is a phenomenon in which saturated, cohesionless soils are temporarily transformed into a near liquid or "quick-sand" state. During an earthquake, ground shaking may result in a buildup of pore water pressure in the saturated soil to a point where the pore water pressure approaches the grain-to-grain contact pressure. As this occurs, the soil particles begin to loose contact with each other and the soil liquefies. The effects of liquefaction include lateral spreading (permanent lateral ground displacements up to about 10 feet on near-level ground), differential settlement, loss of vertical and lateral foundation support, and buoyant rise of buried structures. Historically, soils that have high liquefaction susceptibility include artificial fill (particularly along or in bodies of water) and granular Holocene geologic deposits (e.g., alluvium) in valley bottoms and along rivers and creeks.

Regional liquefaction studies (Grant and others, 1992; Palmer, 1992; Palmer and others 1994, 1995a, 1995b) indicate that late Pleistocene, non-glacially overridden deposits have a moderate to low liquefaction susceptibility, while Pleistocene and older, glacially-overridden sediment and rock have a low liquefaction susceptibility. The Geologic Map, Figure 3, shows the locations of these deposits along the alternative alignments. Liquefaction impact levels were assigned to these units as follows:

- <u>High liquefaction impact</u> was assigned to Holocene alluvium along the Cedar River.
- <u>Moderate to low liquefaction impact</u> was assigned to Pleistocene, recessional glacial outwash near the Cedar River.
- <u>No liquefaction hazard</u> was assigned to all other deposits.

Soft Ground Amplification Impact Levels – Earthquake ground motion or waves can resonate in relatively soft, cohesive soil resulting in local ground motion amplification. The amount of ground motion amplification depends on the characteristics of the earthquake and the thickness and properties of the soil. Soft, cohesive soil (e.g., clay, peat, and organic soils) are typically geologically-recent alluvial deposits that are commonly located in valley bottoms, depressions in bedrock or glaciated uplands, and along rivers and lakes.

- High soft ground amplification impact was assigned to areas indicated to be underlain by Holocene (non-glacially overridden) peat and bogs.

- No soft ground amplification impact was assigned to all other areas.

Tsunami and Seiche Impact Levels – Earthquake-induced flooding may result from tsunami or seiche waves from open (i.e., oceans) or closed (e.g., lake, reservoir) water bodies. As no significant open or closed water bodies exist along the alternative alignments, flooding due to tsunami or seismic seiche is not a risk.

Fault Ground Rupture Impact Levels – Fault ground surface rupture occurs where movement on a fault propagates to the ground surface, resulting in permanent ground displacement across the fault. It is unlikely that ground surface rupture on either the Seattle or South Whidbey Faults would affect the project corridor due to the distance between the corridor and the faults (8 miles). Furthermore, while movement apparently has occurred on these faults in the last 10,000 years, preliminary recurrence interval estimates for earthquakes that could cause ground rupture are on the order of 1,000 to 7,000 years. The three faults mapped within the project corridor do not show evidence of ground rupture for at least the last 13,500 to 15,000 years.

- High fault rupture hazard was assigned to areas along and adjacent to potentially active faults.

- Low fault rupture hazard was assigned to all other areas where unidentified faults could be present.

4.2.2 Seismic General Impacts

Liquefaction – Construction of the project generally would not affect the liquefaction susceptibility of the soil. Transmission line tower foundations built on soil that is susceptible to liquefaction could settle differentially and/or displace laterally during strong ground motion. Depending on the magnitude of movement and/or lateral spreading that occurs, the tower could be rendered unusable, or in extreme conditions, the tower could fail. Under these circumstances, additional maintenance and or repairs would be required, which could cause indirect environmental impacts.

Soft Ground Amplification – Towers or substation structures that are founded on soft ground could be subjected to amplified ground motions during an earthquake, causing damage to or failure of the structure. Soft ground amplification related damage could have indirect environmental impacts caused by additional maintenance work and or construction of new towers damaged during an earthquake.

Soft ground is not present along the alternatives and the Echo Lake Substation expansion area. Therefore, the planned structures would be in low soft ground amplification hazard areas.

Fault Ground Rupture – If an unidentified active fault is present at a tower location and the fault ruptures, the tower could be damaged or fail, which could cause indirect environmental consequences during maintenance or repairs.

No potentially active faults have been identified in the project area; therefore, there are no high fault rupture hazard areas. Because unidentified faults could be present, the entire project area has a low fault rupture hazard.

4.2.3 Alternative 1 Seismic

4.2.3.1 Impacts

High liquefaction hazard may be present in some recent alluvial deposits along the Cedar River. The hazard would be greatest in saturated sand deposits, which are relatively uncommon. Most Cedar River alluvium is gravelly and cobbley, which tends to have a lower liquefaction hazard. We understand towers will not be located close to the Cedar River so that liquefaction should not be a concern.

Moderate to low liquefaction may be present in the recessional outwash sediments between the tap into the Schultz-Raver No. 2 line and the Cedar River, and for about 1/3 mile north of the Cedar River. Liquefaction only occurs in saturated cohesionless soil. Based on gravel pits that we observed close to the proposed alignment, the depth to groundwater is apparently relatively deep. These conditions tend to reduce the potential for liquefaction and reduce the likely damage that would occur if the soil does liquefy. In our opinion, the potential for liquefaction in the recessional outwash deposits is low.

No liquefaction hazard was identified along the remainder of the Alternative 1 alignment.

4.2.3.2 Mitigation

Liquefaction susceptible soil can be improved and/or foundations can be designed to resist liquefaction-related damage. We recommend conducting a site-specific subsurface study prior to final design and construction to evaluate the liquefaction susceptibility of structures that would be built in moderate liquefaction hazard areas.

4.2.3.3 Cumulative Impacts

No cumulative impacts would be associated with seismic hazards.

4.2.4 Alternative 2

Impacts, mitigation, cumulative impacts and unavoidable effects, irreversible or irretrievable commitments of resources for Alternative 2 would be essentially the same as along Alternative 1 (see Section 4.2.3).

4.2.5 Alternative 3

4.2.5.1 Impacts

Liquefaction hazard and consequent potential impacts would be the same as Alternative 1 (see Section 4.2.3.1) except as follows. High liquefaction hazard is present where Alternative 3 crosses Holocene alluvium near Taylor Creek (Sheet 3, Figure 3). Moderate to low liquefaction may be present in the recessional outwash sediments between Anacortes Road and the Cedar River, and for about ¼ mile north of the Cedar River. While geologic units with low to high liquefaction hazard are present, shallow groundwater required for liquefaction would be more likely for tower locations founded close to the river elevation, such as the low banks where Alternative 3 would cross the Cedar River. The Holocene alluvium near Taylor Creek is relatively high above the Cedar River. Therefore, we anticipate that groundwater would be relatively deep, and consequently the liquefaction hazard would be low.

4.2.5.2 Mitigation

Refer to measures under Alternative 1, Section 4.1.4.2.

4.2.5.3 Cumulative Impacts

Refer to measures under Alternative 1, Section 4.1.4.3.

4.2.6 Alternative 4A

Impacts, mitigation, cumulative impacts and unavoidable effects, irreversible or irretrievable commitments of resources for Alternative 4A would be essentially the same as along Alternative 1 (see Section 4.2.3).

4.2.7 Alternative 4B

Impacts, mitigation, cumulative impacts and unavoidable effects, irreversible or irretrievable commitments of resources for Alternative 4B would be essentially the same as along Alternative 1 (see Section 4.2.3).

4.3 Hydrology and Climate

4.3.1 Hydrology, Water Quality and Climate Impact Levels

4.3.1.1 Floodplain Impact Levels

Construction and development can directly impact floodplains by obstructing or changing floodwater channels, which could increase downstream flows and/or upstream flooding. Indirect impacts can occur when resources are degraded (e.g., vegetation is removed and soil is compacted) enough to lessen the ability of the floodplain to store excess water, which increases the chance that flooding will occur.

A floodplain impact would occur when structures or permanent access roads encroach on designated floodplains and increase the potential for flooding, or might cause loss of human life, personal property, or natural resources within the floodplain.

No impacts would occur where floodplains are avoided or spanned, or where standard mitigation would effectively eliminate impacts.

4.3.1.2 Water Quality Limited Water Bodies Impact Levels

The water quality limited water bodies impact is assigned as follows:

- High 303(d) water quality impact is assigned to any water body that is on the Washington State 303(d) list and is crossed by the proposed alternative routes.

- No 303(d) water quality impact was assigned to the remaining areas.

No 303(d) listed waters are currently present in the project area. However, all of the alternatives cross portions of the City of Seattle Cedar River Watershed, which supplies drinking water to the City of Seattle and some surrounding water districts.

4.3.1.3 Groundwater Impact Levels

Although there is no known wellhead protection program for the project area, residential wells do exist in this area. Groundwater impact is assigned as follows:

- High groundwater impact is assigned to areas within a 100-foot radius of groundwater wells.

- Moderate groundwater impact is assigned to private land where groundwater wells likely exist within ½-mile.

- Low groundwater impact was assigned to the remaining areas.

4.3.1.4 Wind Impact Levels

Table 7 of the Soil Survey of Snoqualmie Pass Area (USDA, 1992) and Table 2 in this report show windthrow hazard for each soil unit. Ratings of windthrow impacts were assigned based on these hazard ratings, which range from slight to severe. The ratings are based on soil characteristics that affect root development and the ability of the soil to hold trees firmly, as follows:

- High windthrow impact was assigned to soil units where many trees could be blown over by moderate or strong winds. One soil unit with severe windthrow hazard, Humaquepts silt loam, is present for a short distance where Alternatives 2 and 3 cross Anacortes Road.

- Moderate windthrow impact was assigned to soil units where some trees could be blown over by moderate or strong winds when the soil is wet. Moderate windthrow hazard is present across about half of the project area.

- Low windthrow impact was assigned to soil units where under normal conditions, no trees are blown over. Strong winds could damage some trees but no trees would be uprooted.

- No windthrow impact would be assigned only to areas that are not affected by the construction and maintenance of the proposed project.

4.3.2 Hydrology, Water Quality and Climate General Impacts

Floodplains and Flooding – The proposed transmission line construction, operation and maintenance would not occur in the narrow floodplains or narrow incised stream valleys. Therefore, there should be no impacts to floodplains. The following sections do not discuss floodplains further, because no impacts are anticipated.

Surface water runoff is typically more rapid from areas that have been cleared of large vegetation and/or have disturbed soil than it is from areas with a mature forest canopy and/or with undisturbed soil. The forest canopy intercepts and temporarily stores rainfall, much of which may evaporate. The remaining stored rainfall eventually reaches surface water or groundwater, but over a longer time than rain falling on unforested ground. Forested areas typically return more moisture to the atmosphere by evapotranspiration, which reduces the total amount of runoff, and thus, more runoff would occur more rapidly after an area is cleared.

Disturbed soil is generally less permeable than undisturbed soil. Therefore, rainfall is more likely to runoff directly to streams from areas of disturbed soil than from undisturbed soil where rainfall typically infiltrates. While these impacts would occur along ROW clearings, access roads, and in the substation, the total area affected is small in comparison to the watersheds they cross.

Water Quality – The proposed alternative transmission line routes cross the Cedar River, Raging River, Rock Creek, Taylor Creek, Steele Creek, and/or Canyon Creek. At this time, none of these water bodies are listed on the Washington State 303(d) water quality limited water bodies list for the project area. Therefore, no water quality limited water bodies would be affected by construction of a new transmission line and associated roads.

While 303d limited water bodies are not present in the project area, the construction, operation and maintenance of the project, and especially ROW clearing and access road construction, could impact streams and rivers. As discussed in the following paragraphs, most impacts would occur for a short time. Overall, construction, operation and maintenance impacts are expected to be low and localized. The impacts to water quality are related to the landslide and soil erosion impacts, which are discussed in Section 4.1.

Short term impacts to water quality would be associated with ground disturbance from ROW clearing, building access roads, foundations and towers, and stringing cables. Clearing, exposing and disturbing soil increases erosion, runoff, and the risk of sediment reaching surface waters. Access road construction requires complete vegetation removal and grading, which typically disturb more soil than ROW clearing. The impacts are most intense during and immediately after construction. Impact intensity would diminish as disturbed sites are stabilized and revegetated, which reduces runoff and erosion.

In the long term, increased clearing in the watershed could create foraging habitat that could attract deer, elk and other warm-blooded animals that are potential sources of pathogens and viruses such as giardia and cryptosporidium. Turbidity from subbasins included in the project area contribute to the turbidity in the Cedar River. The Cedar River Watershed Habitat Conservation Plan (SPU, 1999) found that road surface erosion may contribute significant amounts of fine sediment. The amount of erosion increases with increasing traffic volumes on the roads, such as during the construction phase of this project. To a small degree, the temperature of surface water could be affected by reductions in shade where the ROW clearing crosses streams.

Groundwater – Construction and maintenance activities generally would not directly or indirectly introduce contaminates into groundwater aquifers. The project should not affect the chemical or biological characteristics of groundwater in the area. However, uncontrolled accidental spills from construction fuels and lubricants could infiltrate into, and contaminate, the aquifers that provide groundwater for residences, such as in the community of Selleck. BPA commonly uses herbicides during maintenance activities in conjunction with concurrence of landowners.

Wind – Trees typically develop firmness against prevailing winds. However, logging can alter the speed and direction of wind against which the trees have developed firmness. In addition, trees typically shelter each other from winds; however, this sheltering effect is lost for trees exposed along the edges of clearcuts. Therefore, windthrow may be more likely along areas logged and maintained for the transmission line tower alignment. High winds can also affect the transmission line towers and conductors.

The main impacts from windthrow are loss of timber resources, possible damage to structures, and exposing soil to erosion. Section 4.1.2 describes soil erosion impacts.

Impacts related to ROW clearing likely would decrease in the first years after construction. New trees growing adjacent to the ROW clearing, and to some extent trees that survive windstorms following construction, would develop firmness against wind and resist windthrow in the long term.

4.3.3 Alternative 1

4.3.3.1 Impacts

Flooding – As discussed in Section 4.3.2, the proposed project would not affect floodplains. However, the ROW clearing and access road construction would increase the peak runoff and total annual runoff somewhat. These impacts would be most intense during and following construction. As brushy vegetation becomes well established in the ROW clearing, the impacts would decrease. Because the cleared area is small in comparison to the drainage basin, the peak and total amount of runoff would not be noticeable in the Cedar River, Raging River, and their major tributaries. As a result, the relative increase in peak flow in any one watershed would be minor and have only low to no impacts.

Water Quality – Construction-related landslides, soil erosion, ROW clearing activities, and permanent forest canopy removal along the ROW could affect water quality, as discussed in Section 4.3.2. Because Alternative 1 would follow the existing Raver-Echo Lake 500-kV line, new access road construction would be limited to improving the existing trunk access roads and new spur roads to the tower locations. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water resources. Most potential landslide and soil erosion impacts would be short term.

Surface water runoff containing fuel spills, herbicide runoff and other contaminants can reach the main stream discharging from the drainage basin. Two major drainage basins could be affected as follows. Approximately 4.4 miles of the new line would be within the Cedar River Watershed boundaries. About 5.3 miles of the new line would be in the upper Cedar River drainage basin and the remainder would be in the Raging River drainage basin.

From south to north, Alternative 1 crosses the Cedar River, Rock Creek, and three small tributaries of Rock Creek, two tributaries of the Raging River and the Raging River. The transmission line could cross numerous small streams that are not shown on maps. The banks of the Cedar River and the Raging River are relatively high, such that vegetation close to the stream could be left in place to preserve shade. However, where Alternative 1 crosses Rock Creek and its various tributaries, the ROW clearing would remove all trees. This clearing would expose the creek to more direct sunlight, possibly causing some increase in water temperature. The impacts from clearing would be most intense during and immediately following construction and would diminish as low-growing vegetation is established over the creek. However, long-term impacts would occur because of the reduction in shade from the forest canopy. The proposed transmission line will generally cross at an angle close to perpendicular to the streams, so that a relatively short distance of the stream (i.e., 150 to 200 feet) would be affected. The impacts should be small, because the ROW clearing would occur over a small portion of the creek channels. For example, approximately 600 feet of creek channel in the Rock Creek drainage would be in newly cleared ROW, which is less than 1 percent of the more than 60,000 feet of total channel length shown on the USGS 7 ½ minute topographic maps.

Alternative 1 would cross over a pond and wetland area near the center of Section 14, or about 1 mile south of the Echo Lake Substation. Most of this wet area is on the west side of the existing access road. Therefore, little disturbance should occur from construction, operation and maintenance of the proposed new line, which would be on the east side of the access road.

Groundwater – From the tap point of the Schultz-Raver No. 2 line north to the southern Cedar River Watershed boundary, near Pole Line Road, Alternative 1 crosses private land with several residences. These areas are designated as moderate groundwater impact, because the residences likely have groundwater wells for domestic use. Construction- and maintenance-related accidental fuel spills or use of herbicides could potentially affect groundwater quality. The remainder of Alternative 1 crosses low groundwater impact areas that probably do not currently have active groundwater use, including the Cedar River Watershed and private timberland.

Wind – No high windthrow impact areas have been identified along Alternative 1. Soil units that could cause moderate windthrow impact underlie approximately half of Alternative 1, and low windthrow impact soil units underlie the remainder of the alignment. The moderate windthrow impact areas are present along the northern two thirds of Alternative 1, beginning near the angle tower of the Raver-Echo Lake 500-kV line (Soil units 24, 216 and 255 through 258 on the Soil Map, Figure 5). Most of the private timber land north of Brew Hill has been recently clearcut, which essentially eliminates the windthrow hazard. Potential windthrow impacts could occur mainly in the Cedar River Watershed from the angle tower location north to about 3000 feet south of the crest of Brew Hill.

4.3.3.2 Mitigation

Water Quality – Most impacts to water quality will be from construction of roads and ROW clearing, followed by operation and maintenance of roads. Most of the impacts and mitigation measures would be related to soil erosion, as discussed in Section 4.1.3.2. In addition to those mitigation measures, the following measures could be used to reduce impacts on water quality:

- Preserve existing vegetation where practical, and especially adjacent to intermittent and perennial creeks and streams. Plant and encourage riparian vegetation that provides shade for streams and that also meets clearance requirements for the proposed transmission line.
- In the Cedar River Watershed, encourage low-growing vegetation that does not provide foraging habitat for warm-blooded animals such as deer and elk.
- Avoid construction in wetland areas, such as the ponds in Section 14.
- Gate roads to restrict access. While public access is currently not allowed in the Cedar River Watershed, similar restrictions should be imposed on access roads for portions of the alignment that are in the upper Cedar River drainage basin. This would include the area south of Pole Line Road.

- Avoid refueling and/or mixing hazardous materials where accidental spills could enter surface or groundwater.
- Use BMPs to prevent fuel spills and herbicide runoff from reaching streams.
- Avoid or mitigate water quality and fish habitat degradation. Design and maintain roads so that drainage from the road surface does not directly enter streams, ponds, lakes, or impoundments. Direct water off roads into vegetation buffer strips or control through other sediment-reduction practices. Restrict road construction to areas physically suitable based on watershed resource characteristics. While no new bridges or fords are anticipated across larger streams, such as Steele and Rock Creeks, some new roads may cross smaller tributaries to these creeks. At these locations, design stream crossings to avoid adverse impacts to stream hydraulics and deterioration of stream bank and bed characteristics.

Groundwater – BPA would design, construct and maintain the project to comply with local ordinances and laws, and state and federal water quality programs to prevent degradation of the quality of aquifers and not jeopardize their usability as a drinking water source. An on-site refueling plan and spill notification plan would be designed and implemented to protect groundwater quality. During construction and maintenance, refueling and/or mixing hazardous materials would be done in a manner and location that would reduce the potential for accidental spills to impact groundwater.

Prior to using herbicides for ROW maintenance, BPA would contact affected landowners to find out if they have concerns with the use of herbicides on or near their property. BPA's policy on herbicide use in the vicinity of domestic and public drinking water wells is to maintain a 165-foot buffer for any herbicide having a ground or surface water advisory and a 50-foot buffer for any other herbicide. Any herbicide used in construction, operation or maintenance of the proposed project, including the substation, would be EPA-approved and would be applied in accordance with the label instructions.

Wind – Structures and conductors would be designed to resist toppling and excessive sway, respectively. The ROW clearing plan would account for possible windthrow to prevent damage that could affect the transmission line, and potentially affect service or cause a fire. The transmission line would be inspected following severe windstorms to evaluate possible windthrow damage, so that appropriate remedial measures could be implemented as needed for safety and to prevent excessive soil erosion.

4.3.3.3 Cumulative Impacts

Although no waters are 303(d) listed within the project area, potential increases in sedimentation, temperature, or other 303(d) parameters could affect future listings. The potential cumulative impacts on water quality and fish and other habitat would occur mostly from soil disturbing activities, which are described in Section 4.1. In addition, many of the streams will contain populations of fish with special status that may be impacted by the proposed project.

Several impacts discussed in the previous section could affect fish habitat. These include changes in water temperature from clearing vegetation adjacent to stream channels, increased sedimentation, and increased peak runoff resulting from reduced evapotranspiration and interception in cleared areas, and reduced permeability on road surfaces.

4.3.3.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Impacts from roads and ROW clearing will diminish with time, but not completely. Therefore, during the project life, the long-term impacts described in the previous sections would continue. If the transmission line is abandoned, a mature forest canopy could develop, and unused road surfaces would slowly revegetate. Related geology and soils effects and commitments of resources are discussed in Section 4.1.

4.3.4 Alternative 2

4.3.4.1 Impacts

Flooding – The amount of ROW clearing and road construction along Alternative 2 would be similar to Alternative 1. Therefore the impacts would be similar to those described in Section 4.3.3.1.

Water Quality – Most construction-related landslides, soil erosion, ROW clearing activities and maintenance along Alternative 2 would be essentially the same as along Alternative 1. Therefore, the impacts should be similar with the following differences. The portion of Alternative 2 that does not coincide with Alternative 1 would require some additional road building. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water resources. Most potential landslide and soil erosion impacts would be short term.

Surface water runoff containing fuel spills, herbicide runoff and other contaminants can reach the main stream discharging from the drainage basin. Two major drainage basins could be affected as follows. Approximately 4.9 miles of the new line would be within the Cedar River Watershed boundaries. About 5.3 miles of the new line would be in the upper Cedar River drainage basin, while the remainder would be in the Raging River drainage basin.

Alternative 2 would cross the same streams as Alternative 1; however, the Cedar River crossing will be at a low bank. Therefore, all trees and high brush close to the stream would have to be removed. This clearing would expose the river to more direct sunlight possibly causing some increase in water temperature.

Groundwater – Alternative 2 passes east of the community of Selleck before proceeding north into the Cedar River Watershed. The portions of Alternative 2 near this community are designated as moderate groundwater impact areas because they likely use water wells for residential domestic use. Accidental construction- and maintenance-related fuel spills or use of herbicides likely would not directly impact these wells. However, contaminants could migrate in groundwater towards the wells if an accidental spill were to occur upgradient from the wells.

The groundwater gradient was not evaluated in this study. The remainder of Alternative 2 crosses low groundwater impact areas that probably do not currently have active groundwater use, including the Cedar River Watershed and private timberland.

Wind – From the tap point of the Schultz-Raver No. 2 line north to the angle tower on the existing Raver-Echo Lake 500-kV line, about half of Alternative 2 is underlain by soil units designated as moderate windthrow impacts (Soil units 111, 255 and 256 on the Soil Map, Figure 5). A soil unit that could cause a high windthrow impact is present for about 500 feet south of Anacortes Road (Soil unit 79 on the Soil Map, Figure 5). The area south of Anacortes Road was recently clearcut logged, which essentially eliminates the windthrow hazard. Therefore, potential windthrow impacts could occur mainly in the Cedar River Watershed from the angle tower location south for about 4,500 feet to near Rocky Road. Some of this portion of Alternative 2 includes some smaller clearcut areas where there would be no windthrow hazard.

North of the angle tower on the existing Raver-Echo Lake 500-kV line, Alternative 2 follows the same alignment as Alternative 1. Therefore, the windthrow impacts north of the angle tower would be the same as described in Section 4.3.3.1.

4.3.4.2 Mitigation

Refer to measures under Alternative 1, see Section 4.3.3.2.

4.3.4.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.3.3.3.

4.3.4.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.3.3.4).

4.3.5 Alternative 3

4.3.5.1 Impacts

Flooding – The amount of ROW clearing and road construction along Alternative 3 would somewhat greater than along Alternative 1. However, the total disturbed area is small in comparison to the drainage basins; therefore the impacts would be similar to those described in Section 4.3.3.1.

Water Quality – Most construction-related landslides, soil erosion, ROW clearing activities and maintenance along Alternative 3 will be essentially the same as along Alternative 1. Therefore, the impacts would be similar with the following differences. All of Alternative 3 would be on new ROW, such that additional access road would be required, increasing potential impacts on water quality. Most potential landslide and soil erosion impacts would be short term. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water quality.

Surface water runoff containing fuel spills, herbicide runoff and other contaminants can reach the main stream discharging from the drainage basin. Two major drainage basins could be affected as follows. Approximately 5.3 miles of the new line would be within the watershed boundaries. About 5.6 miles of the new line would be in the upper Cedar River drainage basin, while the remainder would be in the Raging River drainage basin.

Alternative 3 would cross the Cedar River at a low bank location so that trees and high brush close to the stream would have to be removed. This clearing would expose the creek to more direct sunlight, possibly causing some increase in water temperature. Alternative 3 crosses other streams including Taylor Creek, Steele Creek, the Raging River headwater creek, Canyon Creek, and three tributary creeks of the Raging River. Clearing along these streams may also cause increases in temperature, although the impacts should be low because of the short length of channel affected.

Groundwater – Alternative 3 does not cross private land where groundwater wells may be present. Therefore, the entire alignment is in a low groundwater impact area.

Wind – The soil units that underlie Alternative 3 for the first 6,000 feet north from the tap point of the Schultz-Raver No. 2 line are designated as moderate and high windthrow impacts (Soil units 216 and 255 {moderate}, and 79 {high} on the Soil Map, Figure 5). Much of this area is south of Anacortes Road, which was recently clearcut logged, essentially eliminating the windthrow hazard. The soil unit that has a severe windthrow hazard is in this clearcut area.

Soil units designated as moderate windthrow impacts underlie most of Alternative 3 from the first proposed angle tower location northeast to the second proposed angle tower location (Soil units 254 and 111 on the Soil Map, Figure 5). Low windthrow hazard is present from the Cedar River crossing north to the Cedar River Watershed boundary. The remainder of Alternative 3 extending north to the Echo Lake Substation crosses soil units that could have moderate windthrow hazard (Soil units 54, 163, and 255 through 258 on the Soil Map, Figure 5). This area has been clearcut logged in the past, although considerable regrowth has occurred in some areas.

4.3.5.2 Mitigation

Refer to measures under Alternative 1, see Section 4.3.3.2.

4.3.5.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.3.3.3.

4.3.5.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.3.3.4).

4.3.6 Alternative 4A

4.3.6.1 Impacts

Flooding – The amount of ROW clearing and road construction along Alternative 4A would be similar to Alternative 1. Therefore, the impacts would be similar to those described in Section 4.3.3.1.

Water Quality – Most construction-related landslides, soil erosion, ROW clearing activities and maintenance along Alternative 4A will be essentially the same as along Alternative 1. Therefore, the impacts would be similar with the following differences. Additional access road building and maintenance would be required along the portions of Alternative 4A that do not coincide with Alternative 1. Most potential landslide and soil erosion impacts would be short term. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water resources.

Surface water runoff containing fuel spills, herbicide runoff and other contaminants can reach the main stream discharging from the drainage basin. Two major drainage basins could be affected as follows. Approximately 5.4 miles of the new line would be within the watershed boundaries. About 5.8 miles of the new line would be in the upper Cedar River drainage basin, while the remainder would be in the Raging River drainage basin.

Alternative 4A would cross the same streams as Alternative 1, with the Cedar River crossing at the same high bank location. Therefore, the impacts at the stream crossings would be the same as along Alternative 1.

Groundwater – Alternative 4A includes the portion of Alternative 2 that east of the community of Selleck before proceeding northwest into the Cedar River Watershed. Section 4.3.4.1 describes potential impacts in this area. The remainder of Alternative 4A crosses low groundwater impact areas that probably do not currently have active groundwater use, including the Cedar River Watershed and private timberland.

Wind – Soil units designated as low windthrow hazard underlie the segment of Alternative 4A that connects between Alternatives 1 and 2. The remainder Alternative 4A is described in Sections 4.3.2.1 and 4.3.3.1, where the alignment coincides with Alternatives 1 and 2, respectively.

Potential windthrow impacts could occur because of ROW clearing for the proposed transmission lines and to a lesser extent, clearing for access roads as described in Section 4.3.2.

4.3.6.2 Mitigation

Refer to measures under Alternative 1, see Section 4.3.3.2.

4.3.6.3 Cumulative Impacts

Refer to measures under Alternative 1, see Section 4.3.3.3.

4.3.6.4 Unavoidable Effects, Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative 1, see Section 4.3.3.4).

4.3.7 Alternative 4B

The impacts, mitigation, cumulative impacts, and unavoidable effects, irreversible or irretrievable commitments of resources for Alternative 4B would be essentially the same as along Alternative 4A. The primary differences are the total length of the alignment is longer, more area in the Cedar River Watershed would be disturbed by ROW clearing, and Pole Line Road would serve as the trunk road where Alternative 4B does not coincide with Alternatives 1 or 2. Approximately 6.0 miles of the new line would be within the watershed boundaries. About 6.4 miles of the new line would be in the upper Cedar River drainage basin, while the remainder would be in the Raging River drainage basin.

Chapter 5 Environmental Consultation, Review and Permit Requirements

The specific permits/reviews that will likely be involved in this project include:

- Army Corps of Engineers (Corps) – Section 404. The Corps Section 404 review process is required for projects involving discharges of dredged or fill materials into the waters of the U.S., including wetlands and streams. Any proposed work located within a jurisdictional wetland and/or below the ordinary high water mark of a stream will require a nationwide permit (NWP) or an individual permit from the Corps. Nationwide permits that may apply to this project include: (1) NWP 7 for outfall structures and maintenance, (2) NWP 12 for utility line activities, and (3) NWP 39 for wetland fills that would not be covered in NWP 12.

- National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) – Endangered Species Act compliance. If the project has a federal nexus (actions authorized, funded, or carried out by federal agencies), a biological evaluation/assessment of the project area would be required to determine whether this project will affect Endangered Species Act (ESA) species or their habitat. Based on the findings of the biological evaluation/assessment, either informal or formal consultation will be required with NMFS and/or USFWS.

- Ecology – Section 401 Water Quality Certification and Coastal Zone Management Consistency. Section 401 Water Quality Certification and a Coastal Zone Management Consistency determination, issued by Ecology may be required as a condition of the Section 404 Nationwide permits for the proposed project. Some general requirements for Section 401, if it is required, include pollution spill prevention and response measures, disposal of excavated or dredged material in upland areas, use of fill material that does not compromise water quality, equipment fueling and washwater discharge restrictions, clear identification of construction boundaries, and site access to permitting agency for inspection.

  If Coastal Zone Management Consistency is required, a brief project description, assessment of project impacts and a statement of whether the project complies with the Coastal Zone Management Program will be required for Ecology's review. If the project is consistent with the Coastal Zone Management Program, Ecology will concur in writing.

- Ecology – Section 303(d). The proposed transmission line routes cross the following water bodies in the project area: Cedar River, Raging River, Rock Creek, Taylor Creek, Steele Creek, and Canyon Creek. At this time, none of these water bodies are listed on the Washington State 303(d) water quality limited water bodies list for the project area (the Cedar River is listed for fecal coliform further west of the project area). Therefore, a 303(d) review most likely will not be required.

- Ecology – Section 402 NPDES Permit to Discharge Stormwater During Construction Activity. The clearing, grading, and/or excavating activities involved with this project are expected to disturb more than 1 acre and would discharge stormwater from the project area into surface water. Land disturbing activities of 1 or more acres require a NPDES

General Permit to Discharge Stormwater associated with construction activity from Ecology. The purpose of this permit is to reduce stormwater pollution from construction activities.

The application for this permitting process is referred to as a Notice of Intent (NOI) and must be submitted to Ecology at least 38 days prior to the start of construction activities. At the time of application, the permittee must also publish a notice in the newspaper that has general circulation within the county in which the project is to take place.

Prior to granting the permit, the applicant must prepare a Stormwater Pollution Prevention Plan (SWPPP) for the project. The SWPP must include Temporary Erosion and Sedimentation Control (TESC) and Spill Control Containment and Countermeasures (SPCC) plans. The SWPPP is not submitted to Ecology, but is required to be kept on site during construction activities and made available to Ecology and local government agencies upon request.

- Washington State Department of Fish and Wildlife (WDFW) – Hydraulic Permit Approval (HPA). A HPA issued by the WDFW is required for any project that uses, diverts, obstructs, or changes the natural flow or bed of any fresh water in the state. General plans for the overall project and complete plans and specifications of the proposed construction are required for the permit submittal. The plans and specifications must include provisions for the proper protection of fish life.

- Washington State Department of Natural Resources (DNR) – Forest Practice Application (FPA). A FPA is required when harvesting timber, constructing roads or applying forest chemicals. The FPA must address road design and layout, and drainage features. The FPA must also address property ownership, harvest plans, and sensitive areas needing protection.

- King County Department of Development and Environmental Services (DDES) – Grading Permit and Environmentally Sensitive Areas Review. A clearing and grading permit is generally required for any earth disturbing project in which:

  1) Cumulative filling and excavating of 100 cubic yards or more;
  2) Filling to a depth of 3 feet or more;
  3) Excavating to a depth of 5 feet or more; or
  4) Clearing, filling or grading in a shoreline area, on steep slopes, in wetlands, or into or next to any body of water or sensitive area.

  One of many exceptions to this requirement is if the clearing and grading occurs in Class II, III or IV Special Forest Practice in a F (Forestry) zone and conducted in accordance with RCW 76.09 and WAC 22. The proposed project appears to lie entirely within a Forestry Production Zone.

  King County will review the proposed project for compliance with the Environmentally Sensitive Areas Ordinance in conjunction with their grading permit review. Environmentally sensitive areas in the project area could include wetlands, streams, flood hazards, erosion hazards, landslide hazards, seismic hazards, coal mine hazards, steep slope hazards, and/or volcanic hazards.

- Wellhead Protection Program. Although there is no known wellhead protection program for the project area, residential wells do exist in this area. Regulatory agencies may require an on-site refueling plan and spill notification plan for this project to protect groundwater quality. Manual tree removal instead of pesticide application may also be required in some areas.

Chapter 6 Individuals and Agencies Consulted

During the course of this study, the following agencies were consulted, either by direct telephone conversations, web sites, or policy publications:

Seattle Public Utilities
King County DDES
Kelly Peterson, Environmental Engineer, City of Kent Wellhead Protection Program
Washington State Department of Natural Resources
Washington State Department of Ecology, Water Quality Program

Chapter 7 Project Study Methods

The objective of this study was to evaluate the geologic, soil, hydrologic and climatic conditions that could be affected by, or could affect, the siting, design, construction, and maintenance of the proposed project. This objective was met by accomplishing the following items of work:

1. **Data Gathering.** Existing available information was collected from government agencies, private companies, and public libraries. The data included:

   - U.S. Geologic Survey (USGS) topographic maps
   - USGS geologic maps and reports
   - USGS seismologic studies
   - Aerial photographs (U.S. Bureau of Land Management and private)
   - U.S. Department of Agriculture soil maps
   - U.S. Forest Service and private timber company soil maps
   - Washington State Department of Natural Resources Division of Geology and Earth Resources maps and charts
   - Private timber company Watershed Analyses studies
   - BPA and Seattle Public Utilities (SPU) geographic information system (GIS) files and maps for the project area
   - Digital orthophoto maps for the project area
   - The Cedar River Municipal Watershed Habitat Conservation Plan by the USFWS

2. **Data Compilation**. The geologic, soil, hydrologic and wind data were compiled and plotted on GIS base maps provided by BPA.

3. **Aerial Photograph Analyses**. We interpreted and mapped geologic features along the alternative routes using stereo pairs of aerial photographs. This mapping focused on identifying features such as landslides, chronic erosion areas, floodplains, and organic soils, using the following aerial photographs:

Date Flown	Color	Approximate Scale	Flight	Source
July 1999	Color	1:25,600	BPA-REL	BPA
June 1995	Black and White	1:12,000	NW-95	WA DNR
August 1983	Infrared	1:48,000	HAP 83F	US ASCS
October 1971	Infrared	1:60,000	NASA 189	NASA
August 1970	Black and White	1:12,000	KP-70	WA DNR
July 1965	Black and White	1:60,000	WF	Pacific Aerial Surveys

WA DNR Washington State Department of Natural Resources
US ASCS United States Agricultural Stabilization and Conservation Service
NASA United States National Aeronautics and Space Administration

4. **Helicopter Overflight**. Following the aerial photographic interpretation and mapping, we flew over each alternative route at low altitude to observe the landforms and ground conditions.

5. **Ground Verification**. Following the aerial photographic interpretation and helicopter overflight, we visited selected locations to verify features identified from the published data and from the aerial photographs. This ground verification concentrated on features such as deeply incised ravines, landslides, erosional areas, apparent soft soil areas, and sensitive water resources.

6. **Technical Report**. The findings of this study are documented in this technical report.

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Glossary

100-year Floodplain – Areas that have a 1 percent chance of being flooded in a given year. (See **Floodplain**.)

Alluvial – Formed by flowing water.

Access road – Roads constructed to each structure site, first to build the tower and line, and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, access roads are built as short spurs to the structure. Access roads are maintained even after construction.

Advance outwash – Glacial outwash that is deposited by, and in front of, an advancing glacier and is subsequently overridden by the glacier. Advance outwash deposits are overconsolidated and typically are very dense.

Alluvium – Clay, silt, sand, gravel, or similar material deposited by running water.

Alternatives – Refers to different choices of means to meet the need for action.

Andesite – A moderate-colored volcanic rock containing iron and magnesium minerals and quartz. Andesite is usually derived from Cascade volcanoes.

Anticline – A convex-up fold, the core of which contains stratigraphically older rocks.

Aquifer – Water bearing rock or sediment below the ground surface.

Basalt – A dark-colored volcanic rock containing iron and magnesium minerals, usually covering an extensive area.

Bedding (geologic) – The arrangement of a sedimentary deposit or rock in beds or layers of varying thickness and character.

Bedrock – The solid rock that underlies the soil and other unconsolidated material that is exposed at the surface.

Best management practices (BMP) – A practice or combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

BPA – Bonneville Power Administration

Breccia – A coarse-grained clastic rock composed of large (greater than sand-sized), angular, and broken rock fragments that are cemented together in a finer-grained matrix. Breccia is similar to conglomerate except that most of the fragments have sharp edges and unworn corners.

Clast - An individual constituent, grain, or fragment of a sediment or rock, produced by the disintegration of a larger rock mass.

Clastic – Pertaining to or being a rock or sediment composed principally of clasts that have been transported individually for some distance from their places of origin.

Claystone – An indurated clay having the texture and composition, but lacking the fine lamination of shale.

Coal – A readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume carbonaceous material that was formed from compaction and induration of plant remains similar to those in peat.

Cohesive – Said of a soil that has relatively high shear strength when wet, e.g., a clayey soil.

Cohesionless – Said of a soil that has relatively low shear strength when air-dried, e.g., a sandy soil.

Colluvial soil, Colluvium – Rock and soil accumulated on or at the foot of a slope.

Conductor – The wire cable strung between transmission towers through which electric current flows.

Conformable – Said of strata or stratification characterized by an unbroken sequence in which the layers are formed one above the other in parallel order. Contrasts with unconformable, in which a period of time is not represented by the strata during which erosion commonly occurred, forming and irregular surface.

Conglomerate – A coarse-grained clastic sedimentary rock composed of rounded fragments larger than 2 millimeters in diameter (granules, pebbles, cobbles, and boulders) set in a fine-grained matrix of sand, silt or cementing materials. The rock equivalent of gravelly soil deposits.

Consolidation – Gradual or slow reduction in volume and increase in density of soil or sediment in response to increased load or compressive stress.

Creep – The slow, continuous downslope movements of soil and rock under the influence of gravity.

Cross-bedding – The internal arrangement of the layers in a stratified rock, characterized by beds or laminae inclined at various angles to the principal bedding plane. It is produced by swift, local, changing currents of air or water. Especially characteristic of sandstone and sand deposits formed in dunes, stream channels and deltas.

Culvert – A corrugated metal or concrete pipe used to carry or divert runoff water from a drainage; usually installed under roads to prevent washouts and erosion.

Cumulative impact – Cumulative impacts are created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Current – the amount of electrical charge flowing through a conductor (as compared to voltage, which is the force that drives the electrical charge).

Cut and Fill – The process where a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (fill).

Danger Trees – Trees or high growing brush in or alongside the ROW, which are hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owner of danger trees off the ROW is compensated for their value. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories: Category A is any tree that within 15 years will grow to within about 18 feet of conductors with the conductor at maximum sag (212^{o} F) and swung by 6 lb. per sq. ft. of wind (58 mph); Category B is any tree or high growing brush that after 8 years of growth will fall within about 8 feet of the conductor at maximum sag (176^{o} F) and in a static position.

DDES – King County Department of Development and Environmental Services.

Debris Flows – Rapid movement of water-charged mixtures of soil, rock, and organic debris.

Dextral shear – Shear movement, as occurs along a fault, where the movement of the side opposite an observer appears to have moved to the right.

Diabase – A dark colored intrusive igneous rock comprised essentially of the minerals labradorite and pyroxene.

Dike (geologic) – A long, narrow, crosscutting mass of igneous or eruptive rock intruded into a fissure in older rock.

DNR – Washington State Department of Natural Resources.

Easement – The grant of certain rights to use a piece of land (which then becomes a "right-of-way"). BPA acquires easement for many of its transmission facilities. This includes the right to enter the ROW to build, maintain, and repair facilities. Permission of these activities are included in the negation process for acquiring easements of private land.

Environmental Impact Statement (EIS) – A detailed statement of environmental impacts caused by an action, written as required by the National Environmental Policy Act.

Eocene – An epoch of the lower Tertiary period, lasting 21 million years , after the Paleocene (57.8 mybp) and before the Oligocene (36.6 mybp).

EPA – Environmental Protection Agency

Erosion – The process by which the surface of the earth is worn away by water, wind, glaciers, waves, etc.

ESCP – Erosion and Sediment Control Plan

EPA – Environmental Protection Agency

Evapotranspiration – The combined processes of evaporation and transpiration. Transpiration is the process by which plants take water from the subsurface, convey it through their woody parts, and give off water vapor through their leaves.

Fault (geologic) – A surface or zone of rock fracture along which there has been movement. The amount of movement can range from a few inches to miles.

Fault trace – The line formed where a fault intersects the ground surface.

FEMA – Federal Emergency Management Agency

Floodplain – The surface or strip of relatively smooth land adjacent to a river channel, constructed (or in the process of being constructed) by the present river in its existing regimen and covered with water when the river overflows its banks.

Fluvial – Of or pertaining to a river or rivers.

Footings – The supporting base for the transmission towers. Usually steel assemblies buried in the ground for lattice-steel towers.

Fore-arc – The zone in front (towards the ocean) of an island arc complex.

Formation – The basic stratigraphic unit used in the local classification of rocks that have some character (age, origin, composition) in common.

FPA – Forest Practice Application.

g – Acceleration due to gravity, equal to 9.8 meters/second/second (32.2 feet/second/second).

Gabbro – A dark colored, intrusive igneous rock composed chiefly of the minerals labradorite and augite.

GIS – Geographic Information Systems. A computer system that analyzes graphical map data.

Geotechnical – Pertaining to the properties of soil and rock, such as compaction, stabilization, compressibility, etc.

Glacial drift – A general term for sediment transported and deposited directly by glaciers.

Glacial erratic – A rock fragment carried by glacier ice and deposited when the ice melted some distance from the outcrop from which the fragment was derived. Generally of boulder size, although fragments range from pebbles to house-sized blocks.

Glacial outwash – Stratified sediment, consisting chiefly of sand and gravel, removed or "washed out" from a glacier by meltwater streams and deposited in front of or beyond the terminal moraine or the margin of an active glacier.

Glacial till – Unsorted and unstratified glacial drift deposited directly by and underneath a glacier without subsequent reworking by water from the glacier. Glacial till typically consists of a heterogeneous mixture of clay, silt, sand, gravel, cobbles and boulders that vary widely in size and shape.

Glaciofluvial – Pertaining to the meltwater streams flowing from wasting glacier ice, and especially to the deposits and landforms produced by such streams.

Glaciolacustrine – Pertaining to, derived from or deposited in glacial lakes. Also said of the deposits and landforms composed of suspended material brought by meltwater streams flowing into lakes bordering a glacier.

Glaciomarine – Said of marine sediments that contain glacial material. Similar to glaciolacustrine, except related to marine water that borders a glacier, and containing clastic debris.

Groundwater – The water beneath the surface of the ground. Typically, groundwater occurs in the small pores between grains of soil or in rock.

Group – A major rock stratigraphic unit next higher in rank than formation. Consists of two or more associated formations.

Headwater – The source (or sources) and upper part of a stream, including the upper drainage basin.

Holocene – The upper epoch of the Quaternary period, from the end of the Pleistocene to present time. Sometimes referred to as "Recent".

HPA – Hydraulic Permit Approval.

Hydrogeology – The science that deals with subsurface waters and related geologic aspects of surface waters.

Hydrology – The science dealing with the properties, distribution, and circulation of water.

Ice-contact drift – Stratified glacial drift deposited in contact with melting glacier ice. Normally marked by numerous kettles and hummocky ground.

Indurated – Said of a compact rock or soil hardened by the action of pressure, cementation and heat.

Intermittent – Referring to periodic water flow in creeks or streams.

Intraslab earthquakes – Earthquakes that originate within a subducting slab, or plate, as opposed to originating on the slab or plate boundaries (interslab).

Interglacial – Refers to a period of time when glaciers were not present and between glacial advances.

Intrusive igneous rock – Rock formed when molten rock (magma) is injected into existing rock. The intrusive body can range from a narrow dike or sill to a body that is miles across.

Island arc complex – A generally curved linear belt of volcanoes above a subduction zone, and the volcanic (extrusive) and plutonic (intrusive) rocks formed there.

Kettle (geologic) – A steep sided, usually basin- or bowl-shaped hole or depression without surface drainage in glacial drift deposits. Commonly contains a lake, pond or swamp. Formed by the melting of a large block of stagnant ice (left behind after a retreating glacier) that had been wholly or partly buried in the glacial drift.

kV – kilovolt, one thousand volts

Landform – Any physical, recognizable form or feature of the Earth's surface, having a characteristic shape, and produced by natural causes. It includes major forms such as a plain, plateau, mountain, slope or dune, among others.

Landslide – Any mass movement process characterized by downslope movement of soil and rock, by means of gravity; or the resulting landform. Can also include other forms of mass wasting not involving sliding, e.g. rockfall. The terminology designating particular landslide types generally refers to the landform as well as the process responsible for the landform, e.g. deep-seated landslide, earth flow, etc.

Lattice steel – Refers to a transmission tower constructed of multiple steel members that are connected together to make up the frame.

Liquefaction – The phenomenon in which saturated, cohesionless soils are temporarily transformed into a near liquid or "quick-sand" state. During an earthquake, ground shaking may result in a buildup of pore water pressure in the saturated soil to a point where the pore water pressure approaches the grain-to-grain contact pressure. As this occurs, the soil particles begin to loose contact with each other and the soil liquefies.

Loamy – A soil whose texture and properties are intermediate between a coarse-texture or sandy soil and a fine-textured or clayey soil.

Lodgment till – A very dense glacial till containing a distribution of all soil particles, from clay to boulders, formed beneath a moving glacier and deposited upon bedrock or other glacial deposits. Commonly characterized by fissile structure (capable of being split easily along closely spaced planes) and stones oriented with their long axes generally parallel to the direction of ice movement.

Low-gradient – With gentle slopes.

Magnitude (earthquake) – A measure of the strength of an earthquake or the strain energy released by it, as determined by seismographic observations.

Mass movement – The dislodgment and downhill transport of soil and rock materials under the direct influence of gravity. Includes movements such as creep, debris torrents, rock slides, and avalanches.

Mass wasting – A general term for the dislodgment and downslope transport of soil and rock material under gravitational forces. It includes slow displacements such as soil creep and rapid movements such as earthflows, rockfalls and avalanches.

Miocene – An epoch of the upper Tertiary period, lasting 18.4 million years, after the Oligocene (23.7 mybp) and before the Pliocene (5.3 mybp).

Mitigation – Steps taken to lessen the effects predicted for each resource, as potentially caused by the transmission project. They may include reducing the impact, avoiding it completely, or compensating for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is taken during the design and location process. Other mitigation, such as reseeding access roads to desirable grasses and avoiding weed proliferation, is taken after construction.

mybp – million years before present

NMFS – National Marine Fisheries Service.

NOI – Notice of Intent.

Nonrenewable – Not capable of replenishing.

Normally consolidated – Soil and sedimentary deposits that are consolidated in equilibrium with the overburden pressure.

NPDES – National Pollutant Discharge Elimination System.

NRCS – National Resource Conservation Service (formerly Soil Conservation Service).

NWP – Nationwide permit.

Oligocene – An epoch of the lower Tertiary period, lasting 12.9 million years, after the Eocene (36.6 mybp) and before the Miocene (23.7 mybp).

Outcrop – An area where rock is exposed at the Earth's surface.

Overconsolidated – Said of soil and sedimentary deposits that are consolidated greater than normal for the existing overburden pressure. Commonly caused by large overburden pressures that have subsequently been removed. Soil and sedimentary deposits that were overridden by glacier ice are typically overconsolidated.

Peak ground acceleration – The maximum instantaneous ground acceleration caused by an earthquake.

Perennial – Streams or creeks with year-round water flow.

Permeability – The ease with which a fluid will move through a porous medium, such as rock or soil.

Physiographic province - A region all parts of which are similar in geologic structure and climate and which has consequently had a unified geomorphic history; a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

Plate tectonics – Global tectonics base on an Earth model characterized by a small number (10-25) of large broad thick plates (blocks composed of continental and oceanic crust and mantle) each of which floats on a viscous underlayer in the mantle and move more or less independently of the other plates. At their margins, plates move away from each other at sea-floor spreading centers where new oceanic crust is created, move towards each other where one plate is subducted below the other, or move next to each other along a strike-slip fault.

Pleistocene – An epoch of the Quaternary, lasting 2 million years, after the Pliocene (2 mybp) and before the Holocene (0.01 mybp).

Quaternary – The second period of the Cenozoic era (following the Tertiary) thought to cover the last two or three million years; includes the Pleistocene and Holocene epochs.

Rainsplash erosion – Erosion that occurs when raindrops impact bare soil and incorporate soil particles in the water that splashes. On a slope, more of the rainsplash moves downslope, resulting in a net downslope soil movement.

Ravel – The downslope movement of single, granular particles, usually as a result of result of gravity.

Ravine – A small, narrow, deep, steep-sided depression, less precipitous than and not as grand as a gorge, smaller than a canyon but larger than a gully. Usually carved by running water.

Recessional outwash - Glacial outwash deposited by a receding glacier. Recessional outwash deposits are normally consolidated and typically are loose to medium dense.

Redd – nest of salmonid eggs deposited in a gravel pocket.

Residual soil, residuum – An accumulation of rock debris and soil formed by weathering and remaining essentially in place as a thin surface layer over the underlying parent material.

Right-of-way (ROW) – An easement for a certain purpose over the land of another, such as a strip of land used for a road, electric transmission line, pipeline, etc.

Rill – A rill is a very small channel made by a small stream (commonly ephemeral).

Riprap – Broken stones put in areas to prevent erosion, especially along river and stream banks.

Sandstone – Sedimentary rock consisting usually of quartz sand, but also feldspar or basalt, united by some cementing agent.

Sediment – Solid fragmental material or mass of such material, either inorganic or organic, that originates from weathering rocks and is transported by, suspended in, or deposited by air, water, or ice and that forms in layers on the Earth’s surface.

Sedimentary – Pertaining to or containing sediment.

Sedimentation – The process of forming or accumulating sediment in layers.

Seiche – A seismically-induced wave that forms on a lake or other closed body of water. Similar to a tsunami but restricted to a closed body of water.

Seismic – Earthquake activity.

Seismogenic – Said of a fault or zone that is capable of generating earthquakes.

Shale – A fissile rock that is formed by the consolidation of clay, mud, or silt, has a finely stratified or laminated structure, and is composed of minerals essentially unaltered since deposition.

Sill (geologic) – A tabular body of igneous intrusion that parallels the planar structure of the surrounding rock. Similar to a dike, except that the orientation of a dike cuts across the planar structure of the surrounding older rock.

Siltstone – A rock composed chiefly of indurated silt.

Single-circuit – A line with one electrical circuit on the same tower.

Slash – Debris left over from harvesting trees.

Slump – Deep, rotational landslide, generally producing coherent movement (back rotation) of blocks over a concave failure surface. Typically, slumps are triggered by the buildup of pore water pressure in mechanically weak materials (deep soil or clay-rock rock).

Soil – All earthy material overlying bedrock.

SPCC – Spill Control Containment and Countermeasures.

SPU – Seattle Public Utilities

Stratified – Formed, arranged, or laid down in layers or strata; especially said of any layered sedimentary rock or deposit.

Stratigraphy – The branch of geology dealing with the classification, correlation and interpretation of stratified rocks.

Structure – Refers to a type of support used to hold up transmission or substation equipment.

Subduction zone – An elongate region along which a crustal block of the earth's surface descends relative to another crustal block.

Subcrustal intraslab earthquake – An earthquake that occurs within a subducting plate beneath the crustal plate.

Substation – The fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Substation rock surfacing – An 8-cm (3-in.) layer of rock selected for its insulating properties is placed on the ground within the substation to protect operation and maintenance personnel from electrical danger during substation electrical failures.

Swale – A low-lying or depressed and sometimes wet stretch of land.

SWPPP – Stormwater Pollution Prevention Plan.

Syncline – A concave-up fold, the core of which contains stratigraphically younger rocks.

Talus – Rock debris that has accumulated at the base of a cliff or steep slope.

Tap – The point at which a transmission line is connected to a substation or other electrical device to provide service to a local load.

Tectonics – A branch of geology concerned with the structure of the crust of a planet (as earth) with the formation of folds and faults in it.

Terrace – An old plain of various origins, ordinarily flat or undulating that borders a river, lake or the sea.

Tonalite – a light colored intrusive igneous rock similar to granite.

Tower – See **Structure**.

Transmission line – The structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Tsunami – A gravitational sea wave formed by any large-scale, short-duration disturbance of the ocean floor, which commonly is an earthquake.

Turbidity – The state or condition or quality of opaqueness or reduced clarity of a fluid, due to the presence of suspended matter.

Upgradient – Refers to slope of the groundwater table. Upgradient is in the upslope direction and opposite to the direction of groundwater flow.

USC – Unified Soil Classification

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

USLE – Universal Soil Loss Equation

Vashon Stade – The middle of three stades of the last glaciation of the Puget Lowland; the most recent stade that reached the central Puget Lowland.

Volcanic – Pertaining to the activities, structures or rock types of a volcano.

Volcanic ash – Fine material formed by a volcanic explosion or aerial expulsion from a volcanic vent.

Volcaniclastic – Pertaining to clastic rocks, containing volcanic material in whatever proportions and without regard to its origin or environment.

Volcanic tuff – A compact deposit of volcanic ash and dust formed by a volcanic explosion or aerial expulsion from a volcanic vent. It may contain up to 50 percent of non-volcanic sediment.

Volt – The international system unit of electric potential and electromotive force.

Voltage – The driving force that causes a current to flow in an electrical circuit.

Water bars – Smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

WDFW – Washington State Department of Fish and Wildlife.

Wetlands – An area where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Windthrow – The uprooting and tipping over trees by wind.

List of Preparers

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Steven A. Mikulencak	Geologist, GIS technician
William J. Perkins, R.P.G	Geologist, Seismic Hazards Specialist
Becki Kniveton	Ecologist
Michelle Iaci	Word Processing
Katie Walter, P.W.S.	Wetland Biologist

TABLE 1: BONNEVILLE POWER ADMINISTRATION
KANGLEY - ECHO lAKE TRANSMISSION PROJECT GEOLOGIC DESCRIPTIONS

Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
QUATERNARY DEPOSITS					
Qa	Alluvium	Holocene	Cedar River: Well sorted pebble to cobble gravel and sand. Smaller streams: thin deposits of sand and gravel.	Very loose to medium dense. Stratified with cross bedding. May contain organic material.	Streambank erosion, ponding, high groundwater, flooding, siltation and potentially liquefiable; locally compressible.
Qb	Bog	Holocene	Organic sediment deposited mostly in closed depressions. The thickness is highly variable.	Very soft to medium stiff. Horizontally laminated, rooted and bioturbated.	Poor foundation material that can cause large differential foundation and/or road settlements. Fills potentially unstable. High groundwater and ponded water.
Qls	Landslide	Holocene to Pleistocene	Landslide debris composed of colluvium and/or creek bedrock	No sorting or structure, hummocky topography, and weak slip planes	Renewed ground movement, variable foundation strength, poor drainage. Excavations, erosion, fills, drainage modifications or removal of vegetation can reactivate movement.
Qvi	Ice Contact Deposits	Pleistocene	Pebbly sand and pebble-cobble gravel, with occasional boulders. Forms kames, kame terraces and eskers.	Loose to dense. Well sorted and stratified to poorly sorted and massive deposits.	Variable strength and drainage characteristics, low liquefaction potential. Scattered boulders may impede excavation.
Qvr	Glacial Outwash (Recessional)	Pleistocene	Sand, pebble-cobble gravel, and silty sand to silty clay.	Stratified, moderately to well sorted sand and gravel to well bedded silt and clay. Loose to dense, variable permeability.	Variable strength and drainage characteristics, cut slopes can ravel due to lack of cohesion, low liquefaction potential. Scattered boulders may impede excavation.
Qvt	Glacial Till	Pleistocene	Gravel and occasional boulders in a silty sand matrix. Glacial till deposits are typically 10 feet thick, but may be as thick as 50 feet.	Dense to very dense. Typically massive and unsorted to poorly sorted, may contain lenses of sand.	Typically high load-bearing characteristics, but high pore water pressure may exist in perched ground water or in confined sand lenses. Scattered boulders may impede

TABLE 1: BONNEVILLE POWER ADMINISTRATION
KANGLEY - ECHO lAKE TRANSMISSION PROJECT GEOLOGIC DESCRIPTIONS

Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
TERTIARY BEDROCK UNITS					
Tpg	Puget Group, undifferentiated	Middle to Late Eocene	Sandstone, siltstone, claystone and coal, deposited primarily in a fluvial environment.	Sandstone is generally massive to cross bedded. Occasional channel cut-and-fill structures. Fractures, joints, bedding planes and facies contacts.	Adversely oriented, interbedded weak rocks (coal, claystone), bedding planes and joints can form failure planes. High pore water pressures in perched groundwater. Massive rock may require blasting/hydraulic breakers.
Tpr	Renton Formation	Late Eocene	Sandstone, siltstone, claystone and coal deposited in fluvial and nearshore marine environments.	Fine-grained siltstone and claystone interbeds commonly form valleys between more resistant sandstone- capped ridges. Fractures, joints, bedding planes and facies contacts.	Adversely oriented, interbedded weak rocks (coal, claystone), bedding planes and joints can form failure planes. High pore water pressures in perched groundwater. Massive rock may require blasting/hydraulic breakers.
Tpt	Tukwila Formation	Middle to late Eocene	Volcanic lava flows, sills and dikes, tuff, and breccia, with sandstone and conglomerate interbeds.	Flow rocks are more resistant to erosion, and making up most Tukwila Formation outcrops. Fractures, joints, bedding planes and facies contacts.	Interbedded and fractured/jointed weak and strong rocks and zones of highly weathered rock form failure planes. Massive, fresh flow rocks may require blasting/hydraulic breaking.
Tptm	Tiger Mountain Formation	Late early to middle Eocene	Medium-grained sandstone with interbedded siltstone, conglomerate and coal beds.	Fine-grained siltstone interbeds commonly form valleys between more resistant sandstone- capped ridges. Fractures, joints, bedding planes and facies contacts.	Adversely oriented, interbedded weak rocks (coal, claystone), bedding planes and joints can form failure planes. High pore water pressures in perched groundwater. Massive rock may require blasting/hydraulic breakers.
Trr	Raging River Formation	Late early to Middle Eocene	Volcanic sandstone, siltstone and conglomerate deposited in a nearshore marine environment.	Fine-grained siltstone and claystone interbeds commonly form valleys between more resistant sandstone- capped ridges. Fractures, joints, bedding planes and facies contacts.	Adversely oriented, bedding planes and joints can form failure planes. High pore water pressures in perched groundwater. Massive rock may require blasting/hydraulic breakers.

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY - ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
10	Barneston gravelly coarse sandy loam	>60	0.15	0-6	Glacial outwash terraces and volcanic ash.	Slight	Slight
11	Barneston gravelly coarse sandy loam	>60	0.15	6-30	Glacial outwash terraces and volcanic ash.	Slight	Slight
12	Barneston gravelly coarse sandy loam	>60	0.15	30-65	Glacial outwash terraces, terrace escarpments and volcanic ash.	Moderate	Slight
17	Beausite gravelly loam	24-40 Hard	0.20	6-30	Glacial till and colluvium formed from sandstone.	Slight	Moderate
18	Beausite gravelly loam	24-40 Hard	0.20	30-65	Glacial till and colluvium formed from sandstone.	Moderate	Moderate
24	Blenthen gravelly loam	>60	0.24	30-65	Colluvium and slope alluvium formed from glacial drift. Some admixture of volcanic ash.	Moderate	Slight
41	Chuckanut loam	40-60 Soft	0.32	6-15	Mixture of volcanic ash and colluvium derived from sandstone and glacial till.	Slight	Slight
42	Chuckanut loam	40-60 Soft	0.32	15-30	Mixture of volcanic ash and colluvium derived from sandstone and glacial till.	Slight	Slight
43	Chuckanut loam	40-60 Soft	0.32	30-65	Mixture of volcanic ash and colluvium derived from sandstone and glacial till.	Moderate	Slight
45	Cinebar silt loam	>60	0.28	15-30	Loess and slope alluvium high content of volcanic ash.	Slight	Slight
53	Edgewick silt loam	>60	0.37	0-3	River terrace alluvium.	Slight	Slight
54	Elwell silt loam	>60	0.28	6-30	Weathered glacial till and volcanic ash.	Slight	Moderate
55	Elwell silt loam	>60	0.28		Weathered glacial till and volcanic ash.	Moderate	Moderate
63	Gallup loam	>60	0.32	6-30	Mixture of volcanic ash and weathered metasediments.	Slight	Slight
65	Gallup loam, breccia substratum	>60	0.32	30-65	Mixture of volcanic ash and colluvium derived from volcanic rock.	Moderate	Slight
71	Hartnit silt loam	20-40 Hard	0.24	8-30	Mixture of glacial till, volcanic ash, and colluvium derived from volcanic rock.	Slight	Moderate
79	Humaquepts silt loam, silty clay loam and gravelly, silty clay loam	>60	0.37	0-5	Alluvial terraces.	Slight	Severe

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY - ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
95	Kaleetan sandy loam	>60	0.20	30-65	Mixture of volcanic ash and pumice over colluvium derived from tuff, breccia and glacial till.	Moderate	Slight
97	Kanaskat gravelly sandy loam	60-72 Soft	0.15	30-65	Mixture of volcanic ash, colluvium, and material weathered from extrusive rocks.	Moderate	Slight
111	Klaus sandy loam	>60	0.20	0-8	Mixture of volcanic ash and alluvium overlying glacial outwash.	Slight	Moderate
113	Klaus sandy loam	>60	0.20	30-65	Mixture of volcanic ash and alluvium over glacial outwash.	Moderate	Moderate
121	Littlejohn gravelly sandy loam	25-40 Hard	0.15	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from volcanic rock.	Moderate	Moderate
124	Littlejohn gravelly sandy loam, tuff substratum	25-40 Hard	0.15	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from volcanic rock.	Moderate	Moderate
146	Nargar fine sandy loam	>60	0.32	0-15	Mixture of volcanic ash and sandy alluvium over glacial outwash.	Slight	Slight
147	Nargar fine sandy loam	>60	0.32	15-30	Mixture of volcanic ash and sandy alluvium and glacial outwash terraces.	Slight	Slight
148	Nargar-Pastik complex	>60	0.32	35-70	Terrace escarpments of sandy alluvium and glacial outwash, and lake sediments mixed with volcanic ash.	Moderate	Slight
158	Norma loam	>60	0.37	0-3	Alluvium formed in depressions of glacial till.	Slight	Severe
159	Oakes gravelly loam	>60	0.24	6-30	Volcanic ash and colluvium and slope alluvium developed from glacial till.	Slight	Slight
162	Ogarty gravelly loam	20-40 Hard	0.20	8-30	Volcanic ash and colluvium and residuum developed from andesite and breccia.	Slight	Moderate
163	Ogarty gravelly loam	20-40 Hard	0.20	30-65	Volcanic ash and colluvium and residuum developed from andesite and breccia.	Moderate	Moderate
164	Ogarty-Rock outcrop complex	20-40 Hard	0.20	45-90	Mixture of volcanic ash and colluvium and residuum derived from volcanic rock.	Severe	Moderate

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY - ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
172	Ovall gravelly loam	20-40 Hard	0.17	15-30	Glacial drift mixed with colluvium and residuum derived from volcanic rock.	Slight	Moderate
188	Pitcher sandy loam	>60	0.28	8-30	Volcanic ash over colLuvium and residuum developed from andesite.	Moderate	Slight
189	Pitcher sandy loam	>60	0.28	30-65	Volcanic ash over colluvium and residuum developed from andesite.	Moderate	Slight
191	Pitcher sandy loam, tuff substratum	>60	0.28	8-30	Volcanic ash over colluvium and residuum derived dominantly from volcanic rock.	Slight	Slight
192	Pitcher sandy loam, tuff substratum	>60	0.28	30-65	Volcanic ash over colluvium and residuum derived dominantly from volcanic rock.	Moderate	Slight
200	Playco very gravelly loamy sand, tuff substratum	>60	0.10	30-65	Mixture of volcanic ash and pumice and colluvium derived dominantly from volcanic rock.	Moderate	Slight
203	Ragnar loam	>60	0.32	6-15	Glacial outwash.	Slight	Slight
206	Ragnar-Lynnwood complex	>60	0.32	30-45	Glacial outwash.	Moderate	Slight
211	Reichel silt loam	40-60 Hard	0.32	6-30	Mixture of volcanic ash and colluvium and residuum derived dominantly from volcanic rock.	Slight	Slight
212	Reichel silt loam	40-60 Hard	0.32	30-65	Mixture of volcanic ash and colluvium and residuum derived dominantly from volcanic rock.	Moderate	Slight
216	Rober loam	>60	0.32	0-30	Volcanic ash and glaciolacustrine sediments.	Slight	Moderate
237	Skykomish gravelly sandy loam	>60	0.10	0-30	Mixture of volcanic ash and glacial outwash.	Slight	Slight
244	Stahl very gravelly silt loam	20-40 Hard	0.10	30-65	Mixture of volcanic ash and colluvium and residuum derived dominantly from volcanic rock.	Moderate	Moderate
247	Sulsavar loam	>60	0.32	0-8	Mixture of volcanic ash and alluvium.	Slight	Slight
254	Tokul gravelly loam	>60	0.20	0-6	Mixture of volcanic ash and glacial till.	Slight	Moderate

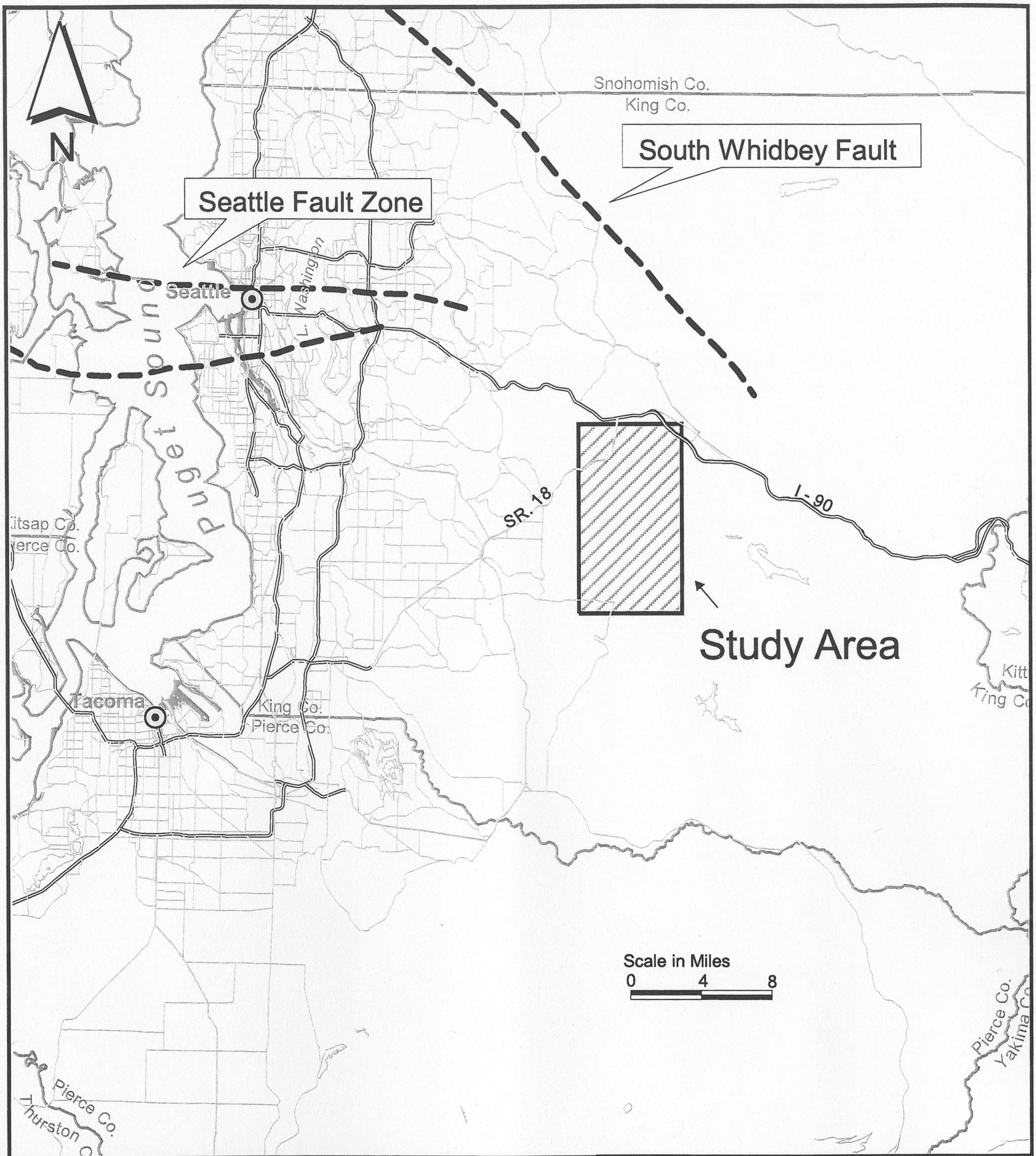
TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY - ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

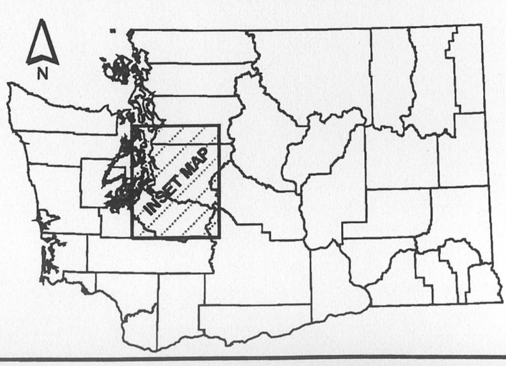
Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
255	Tokul gravelly loam	>60	0.20	6-15	Mixture of volcanic ash and glacial till.	Slight	Moderate
256	Tokul gravelly loam	>60	0.20	15-30	Mixture of volcanic ash and glacial till.	Slight	Moderate
257	Tokul gravelly loam	>60	0.20	30-65	Mixture of volcanic ash and glacial till.	Moderate	Moderate
258	Tokul gravelly loam - Pastik silt loam	>60	0.32	45-90	Mixture of volcanic ash and glacial till and lake sediments.	Severe	Moderate
273	Welcome loam	40-60 Soft	0.28	0-30	Volcanic ash, colluvium and slope alluvium derived from sandstone and modified by glacial till.	Slight	Slight
274	Welcome loam	40-60 Soft	0.28	30-65	Volcanic ash, colluvium and slope alluvium derived from sandstone and modified by glacial till.	Moderate	Slight
278	Winston loam	>60	0.24	0-8	Volcanic ash and glacial outwash.	Slight	Slight

TABLE 3
COMPARISON OF IMPACTS ON ALTERNATIVES

					Soil Erosion (% of Length)				Windthrow (% of Length)	
Alternative	Length (miles)	Clearing[1] (acres)	Deep-[2] Seated Landslide (% of length)	Shallow[3] Landslide (% of length)	Severe	Moderate	Slight	Stream Crossings[4]	High	Moderate
1	9.1	165	6	5	3	15	82	9	0	55
2	9.1	165	6	3	3	15	82	10	1	71
3	10.6	190	4	5	2	20	78	13	1	60
4A	9.6	175	6	5	3	15	82	10	1	60
4B	10.2	185	6	5	3	15	82	10	1	57

(1) Based on 150-foot wide corridor
(2) Moderate and low deep-seated landslide hazard areas
(3) Low shallow landslide hazard areas
(4) Based on intersection of alignment with streams mapped on 1973 Hobart, 1968 North Bend, and 1968 Eagle Gorge USGS 7.5 minute quadrangle maps





Bonneville Power Administration
Kangley-Echo Lake
Transmission Project

VICINITY MAP

January 2001

21-1-09189-001

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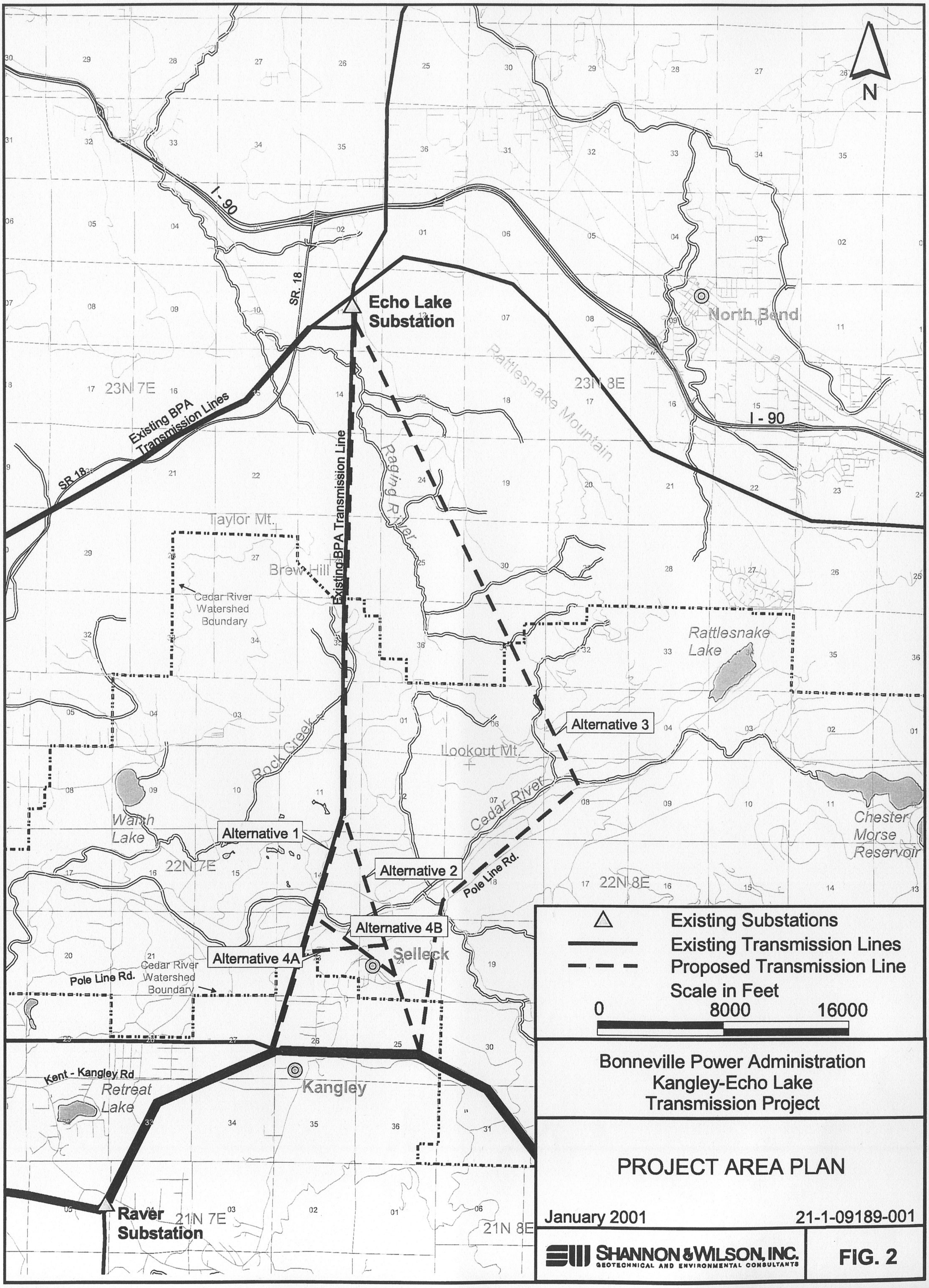
FIG. 1



Bonneville Power Administration
Kangley-Echo Lake
Transmission Project

PROJECT AREA PLAN

January 2001

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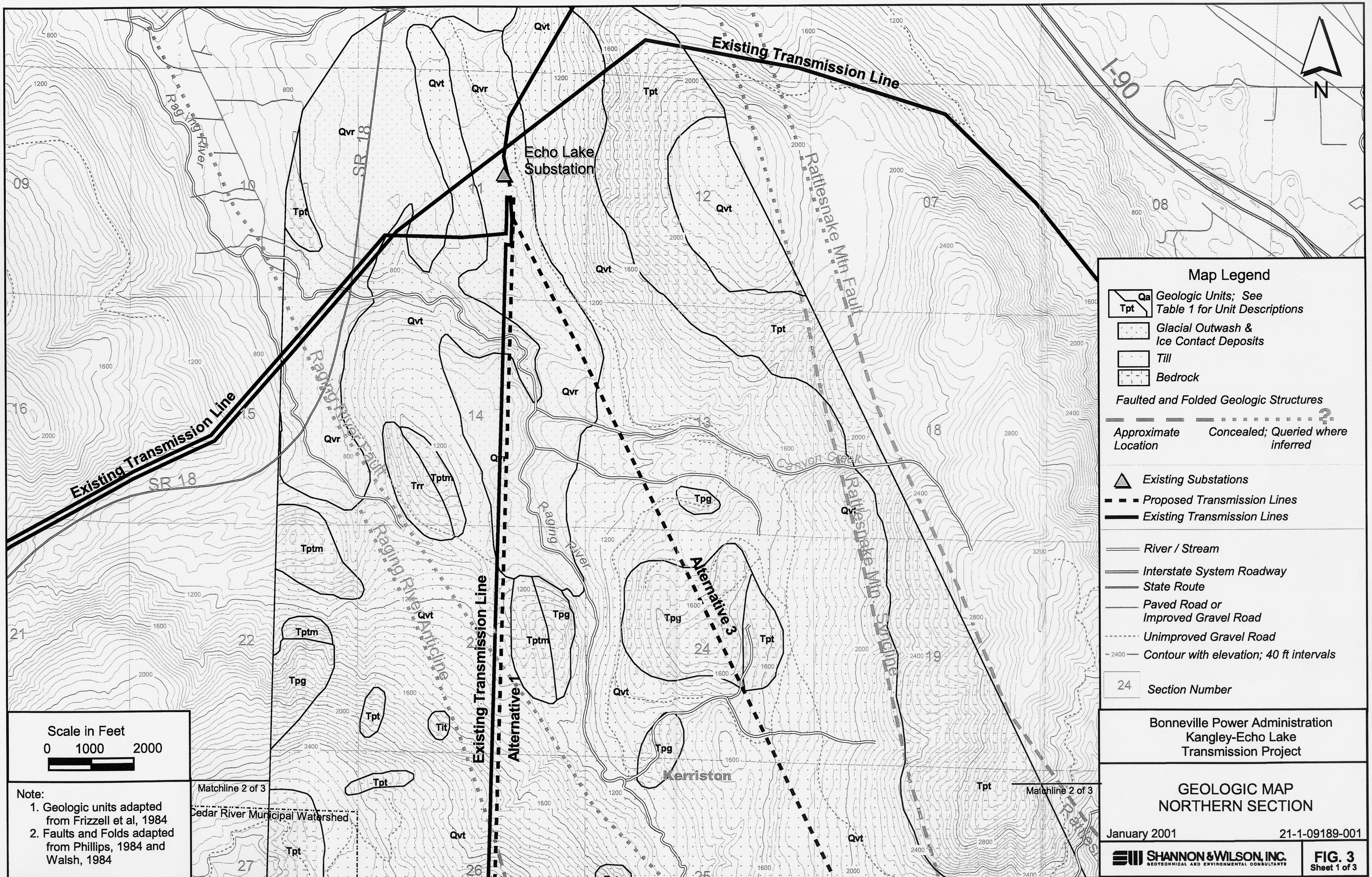
FIG. 2


Existing Transmission Line
Existing Transmission Line
Existing Transmission Line
Existing Transmission Line
Echo Lake Substation
Alternative 1
Alternative 3
Raging River
Raging River Fault
Raging River Anticline
Rattlesnake Mtn Fault
Rattlesnake Mtn Syncline
Canyon Creek
Kerriston
SR 18
I-90
N
Matchline 2 of 3
Cedar River Municipal Watershed
Map Legend
Geologic Units; See Table 1 for Unit Descriptions
Glacial Outwash & Ice Contact Deposits
Till
Bedrock
Faulted and Folded Geologic Structures
Approximate Location
Concealed; Queried where inferred
Existing Substations
Proposed Transmission Lines
Existing Transmission Lines
River / Stream
Interstate System Roadway
State Route
Paved Road or Improved Gravel Road
Unimproved Gravel Road
Contour with elevation; 40 ft intervals
Section Number
Scale in Feet
0 1000 2000
Note:
1. Geologic units adapted from Frizzell et al, 1984
2. Faults and Folds adapted from Phillips, 1984 and Walsh, 1984
Bonneville Power Administration
Kangley-Echo Lake
Transmission Project
GEOLOGIC MAP
NORTHERN SECTION
January 2001
21-1-09189-001
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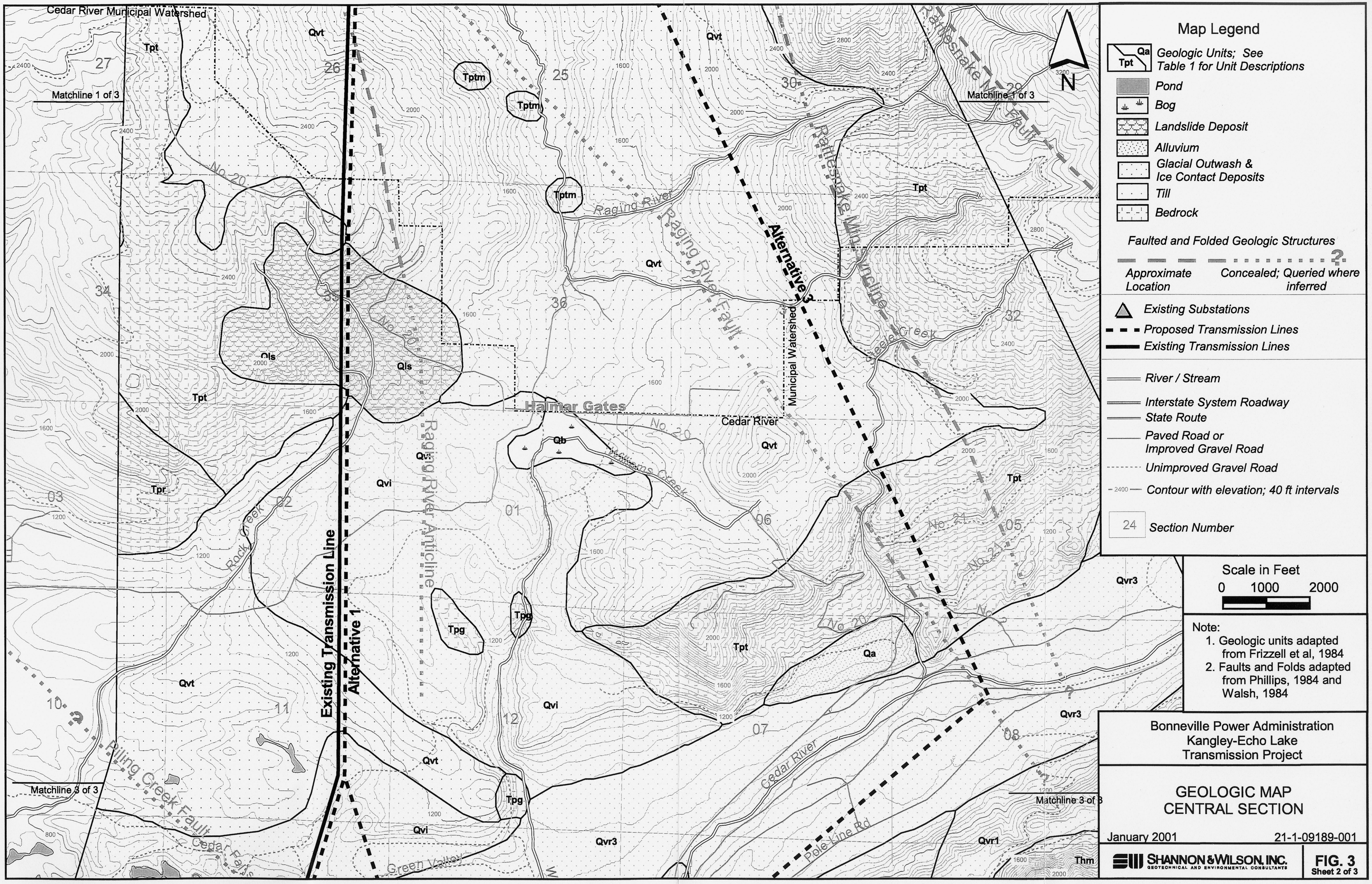
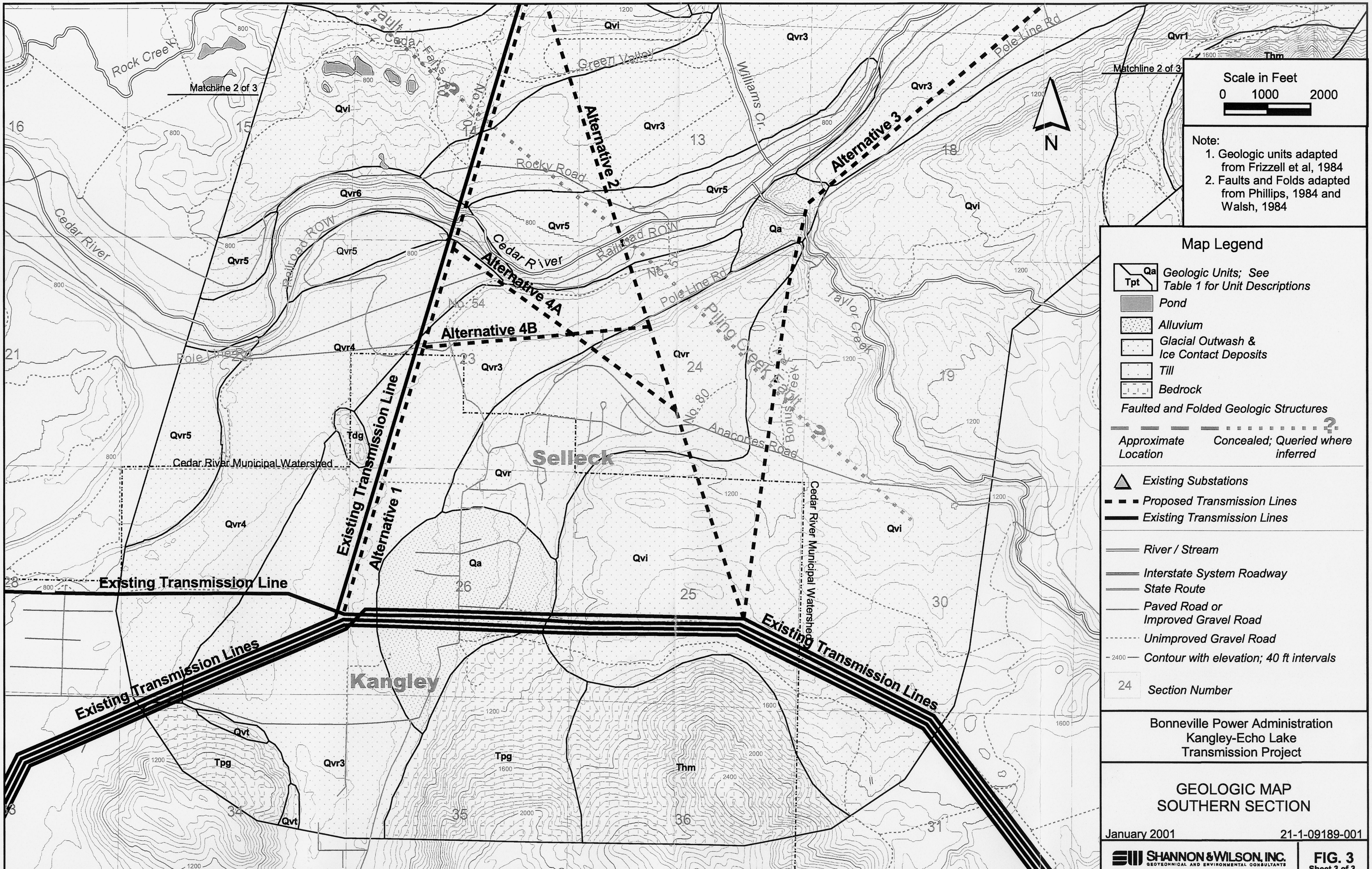
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 3
Sheet 1 of 3


Map Legend
Geologic Units; See Table 1 for Unit Descriptions
Qa
Tpt
Pond
Bog
Landslide Deposit
Alluvium
Glacial Outwash & Ice Contact Deposits
Till
Bedrock
Faulted and Folded Geologic Structures
Approximate Location
Concealed; Queried where inferred
Existing Substations
Proposed Transmission Lines
Existing Transmission Lines
River / Stream
Interstate System Roadway
State Route
Paved Road or Improved Gravel Road
Unimproved Gravel Road
Contour with elevation; 40 ft intervals
Section Number
Scale in Feet
0 1000 2000
Note:
1. Geologic units adapted from Frizzell et al, 1984
2. Faults and Folds adapted from Phillips, 1984 and Walsh, 1984
Bonneville Power Administration
Kangley-Echo Lake
Transmission Project
GEOLOGIC MAP
CENTRAL SECTION
January 2001
21-1-09189-001
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 3
Sheet 2 of 3
N
Cedar River Municipal Watershed
Matchline 1 of 3
Matchline 3 of 3
Existing Transmission Line
Alternative 1
Alternative 3
Raging River Anticline
Raging River Fault
Rattlesnake Mtn. Syncline
Rattlesnake Mtn. Fault
Pilling Creek Fault
Municipal Watershed
Hobart Gates
Cedar River
Raging River
Steele Creek
Williams Creek
Rock Creek
Green Valley
Pole Line Rd
No. 20
No. 21
Qvt
Qvi
Qvr3
Qvr1
Tpt
Tptm
Tpg
Tpr
Qls
Qb
Qa
Thm



Scale in Feet
0 1000 2000
N
Note:
1. Geologic units adapted from Frizzell et al, 1984
2. Faults and Folds adapted from Phillips, 1984 and Walsh, 1984
Map Legend
Geologic Units; See Table 1 for Unit Descriptions
Pond
Alluvium
Glacial Outwash & Ice Contact Deposits
Till
Bedrock
Faulted and Folded Geologic Structures
Approximate Location
Concealed; Queried where inferred
Existing Substations
Proposed Transmission Lines
Existing Transmission Lines
River / Stream
Interstate System Roadway
State Route
Paved Road or Improved Gravel Road
Unimproved Gravel Road
Contour with elevation; 40 ft intervals
Section Number
Bonneville Power Administration
Kangley-Echo Lake
Transmission Project
GEOLOGIC MAP
SOUTHERN SECTION
January 2001
21-1-09189-001
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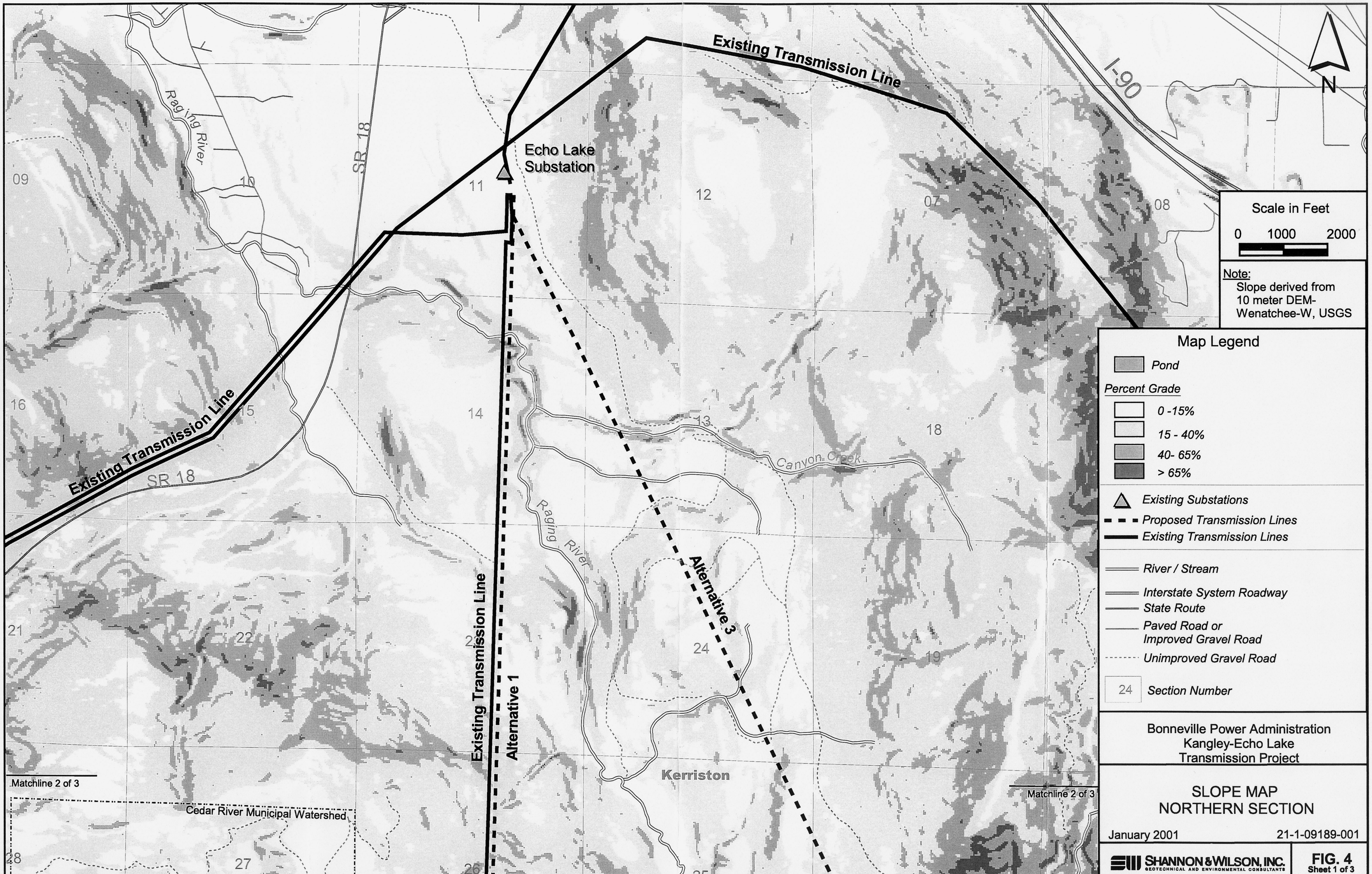
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 3
Sheet 3 of 3
Matchline 2 of 3
Rock Creek
Cedar Falls Rd
Fault
Green Valley
Williams Cr.
Pole Line Rd
Rocky Road
Cedar River
Railroad ROW
Pole Line Rd
Piling Creek Fault
Taylor Creek
Bonus Creek
Anacortes Road
Cedar River Municipal Watershed
Selleck
Kangley
Alternative 1
Alternative 2
Alternative 3
Alternative 4A
Alternative 4B
Existing Transmission Line
Existing Transmission Lines
No. 54
No. 80
Qvi
Qvr3
Qvr1
Thm
Qvr5
Qvr6
Qvr4
Qvr
Qa
Tdg
Tpg
Qvt



N
Existing Transmission Line
I-90
Raging River
SR 18
Echo Lake
Substation
09
10
11
12
07
08
16
15
14
13
18
Existing Transmission Line
SR 18
Canyon Creek
Raging River
Alternative 3
Existing Transmission Line
Alternative 1
21
22
24
19
Kerriston
Matchline 2 of 3
Cedar River Municipal Watershed
28
27
26
25
Matchline 2 of 3
Scale in Feet
0 1000 2000
Note:
Slope derived from
10 meter DEM-
Wenatchee-W, USGS
Map Legend
Pond
Percent Grade
0 -15%
15 - 40%
40- 65%
> 65%
Existing Substations
Proposed Transmission Lines
Existing Transmission Lines
River / Stream
Interstate System Roadway
State Route
Paved Road or
Improved Gravel Road
Unimproved Gravel Road
24 Section Number
Bonneville Power Administration
Kangley-Echo Lake
Transmission Project
SLOPE MAP
NORTHERN SECTION
January 2001
21-1-09189-001
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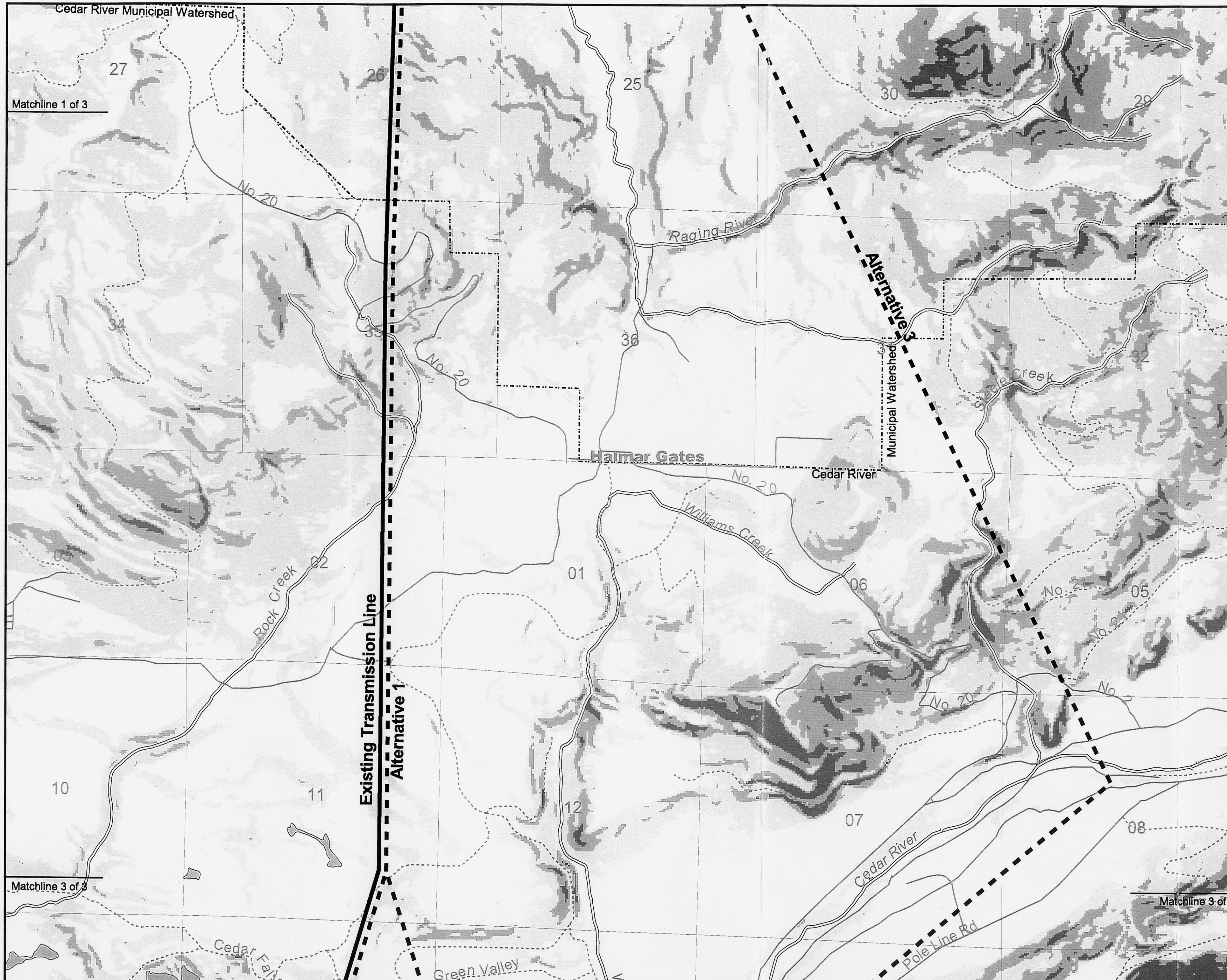
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4
Sheet 1 of 3



Bonneville Power Administration
Kangley-Echo Lake
Transmission Project

SLOPE MAP
CENTRAL SECTION

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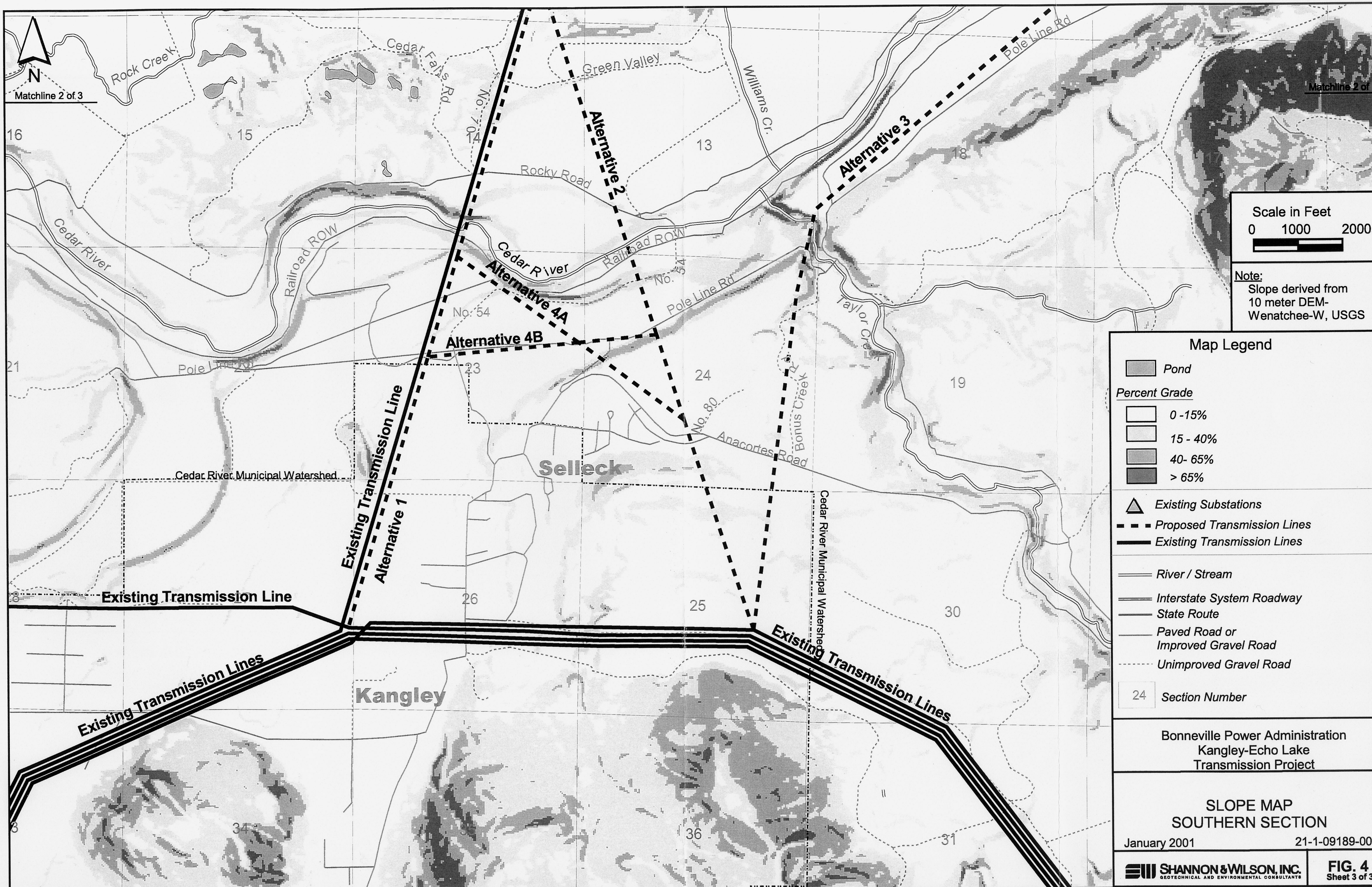
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4
Sheet 2 of 3



Bonneville Power Administration
Kangley-Echo Lake
Transmission Project

SLOPE MAP
SOUTHERN SECTION

January 2001 21-1-09189-001

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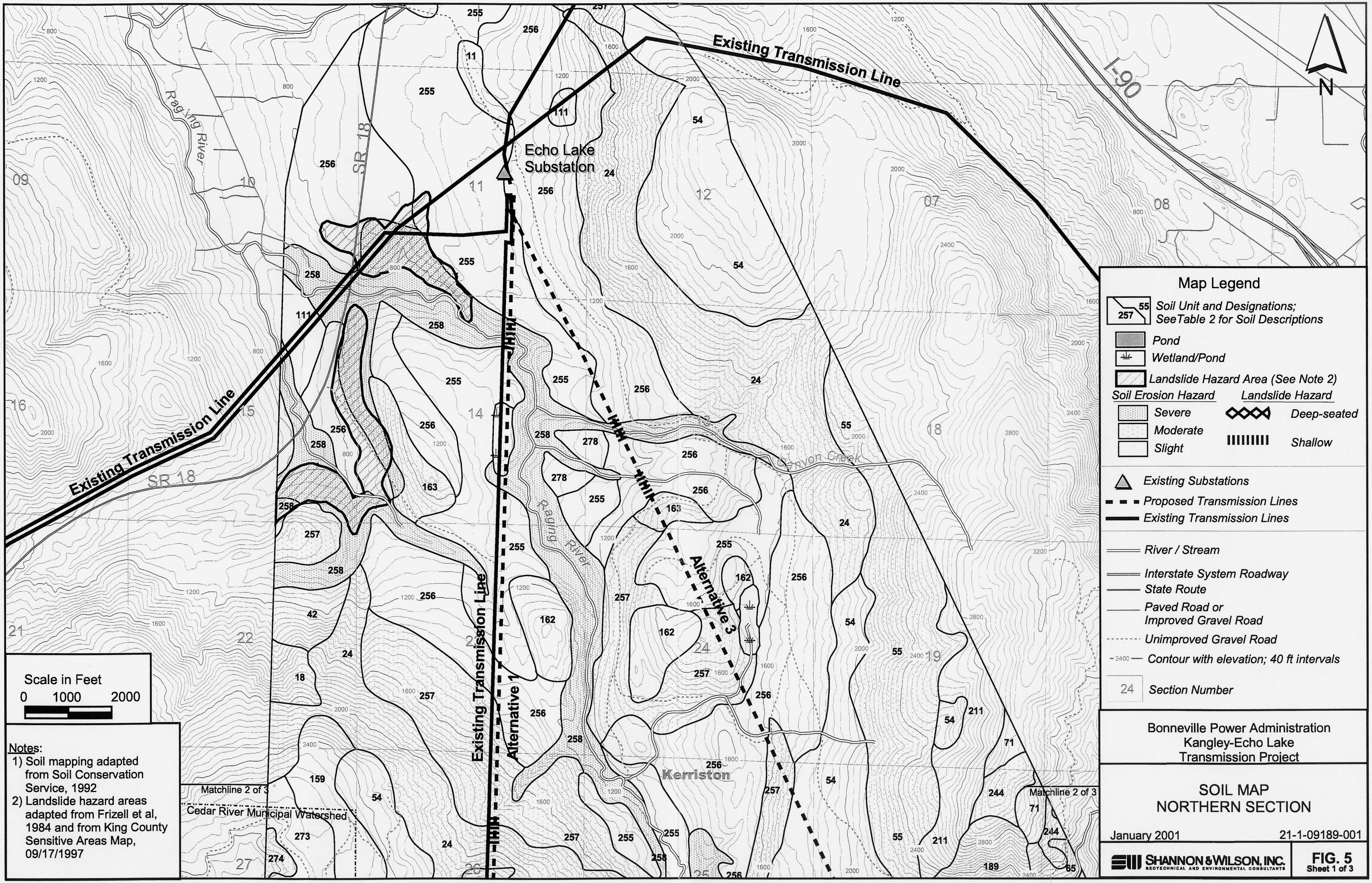
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4
Sheet 3 of 3



Existing Transmission Line
I-90
N
Echo Lake Substation
SR 18
Raging River
Canyon Creek
Kerriston
Alternative 1
Alternative 3
Existing Transmission Line
Map Legend
Soil Unit and Designations; See Table 2 for Soil Descriptions
Pond
Wetland/Pond
Landslide Hazard Area (See Note 2)
Soil Erosion Hazard
Landslide Hazard
Severe
Moderate
Slight
Deep-seated
Shallow
Existing Substations
Proposed Transmission Lines
Existing Transmission Lines
River / Stream
Interstate System Roadway
State Route
Paved Road or Improved Gravel Road
Unimproved Gravel Road
Contour with elevation; 40 ft intervals
Section Number
Scale in Feet
0 1000 2000
Notes:
1) Soil mapping adapted from Soil Conservation Service, 1992
2) Landslide hazard areas adapted from Frizell et al, 1984 and from King County Sensitive Areas Map, 09/17/1997
Matchline 2 of 3
Cedar River Municipal Watershed
Bonneville Power Administration
Kangley-Echo Lake
Transmission Project
SOIL MAP
NORTHERN SECTION
January 2001
21-1-09189-001
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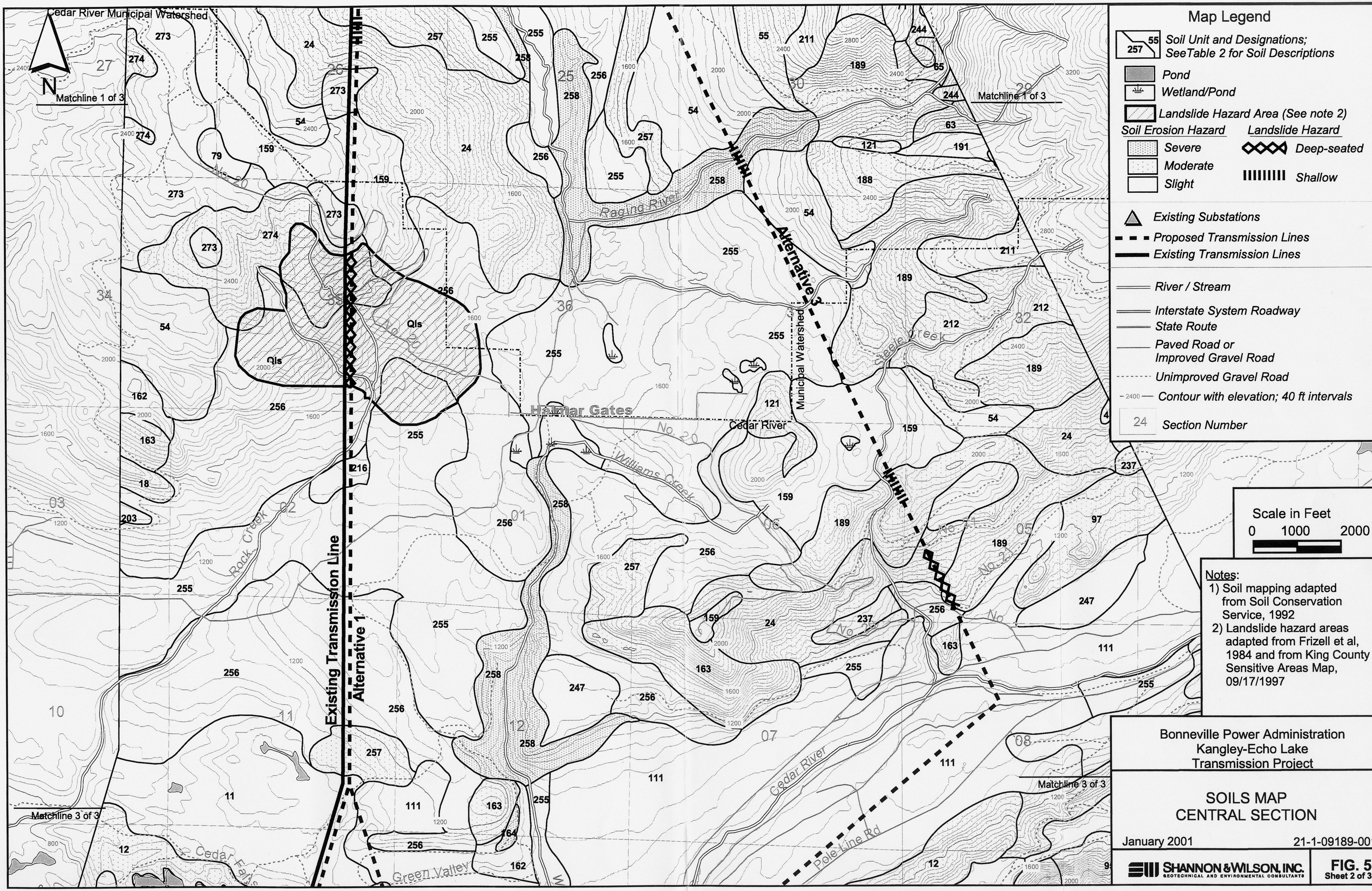
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 5
Sheet 1 of 3


Cedar River Municipal Watershed
Matchline 1 of 3
Matchline 3 of 3
Existing Transmission Line
Alternative 1
Alternative 3
Raging River
Hobart Gates
Cedar River
Williams Creek
Rock Creek
Steele Creek
Municipal Watershed
Pole Line Rd
Green Valley
No. 20
No. 21
Map Legend
Soil Unit and Designations; See Table 2 for Soil Descriptions
Pond
Wetland/Pond
Landslide Hazard Area (See note 2)
Soil Erosion Hazard
Severe
Moderate
Slight
Landslide Hazard
Deep-seated
Shallow
Existing Substations
Proposed Transmission Lines
Existing Transmission Lines
River / Stream
Interstate System Roadway
State Route
Paved Road or Improved Gravel Road
Unimproved Gravel Road
Contour with elevation; 40 ft intervals
Section Number
Scale in Feet
0 1000 2000
Notes:
1) Soil mapping adapted from Soil Conservation Service, 1992
2) Landslide hazard areas adapted from Frizell et al, 1984 and from King County Sensitive Areas Map, 09/17/1997
Bonneville Power Administration
Kangley-Echo Lake
Transmission Project
SOILS MAP
CENTRAL SECTION
January 2001
21-1-09189-001
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 5
Sheet 2 of 3

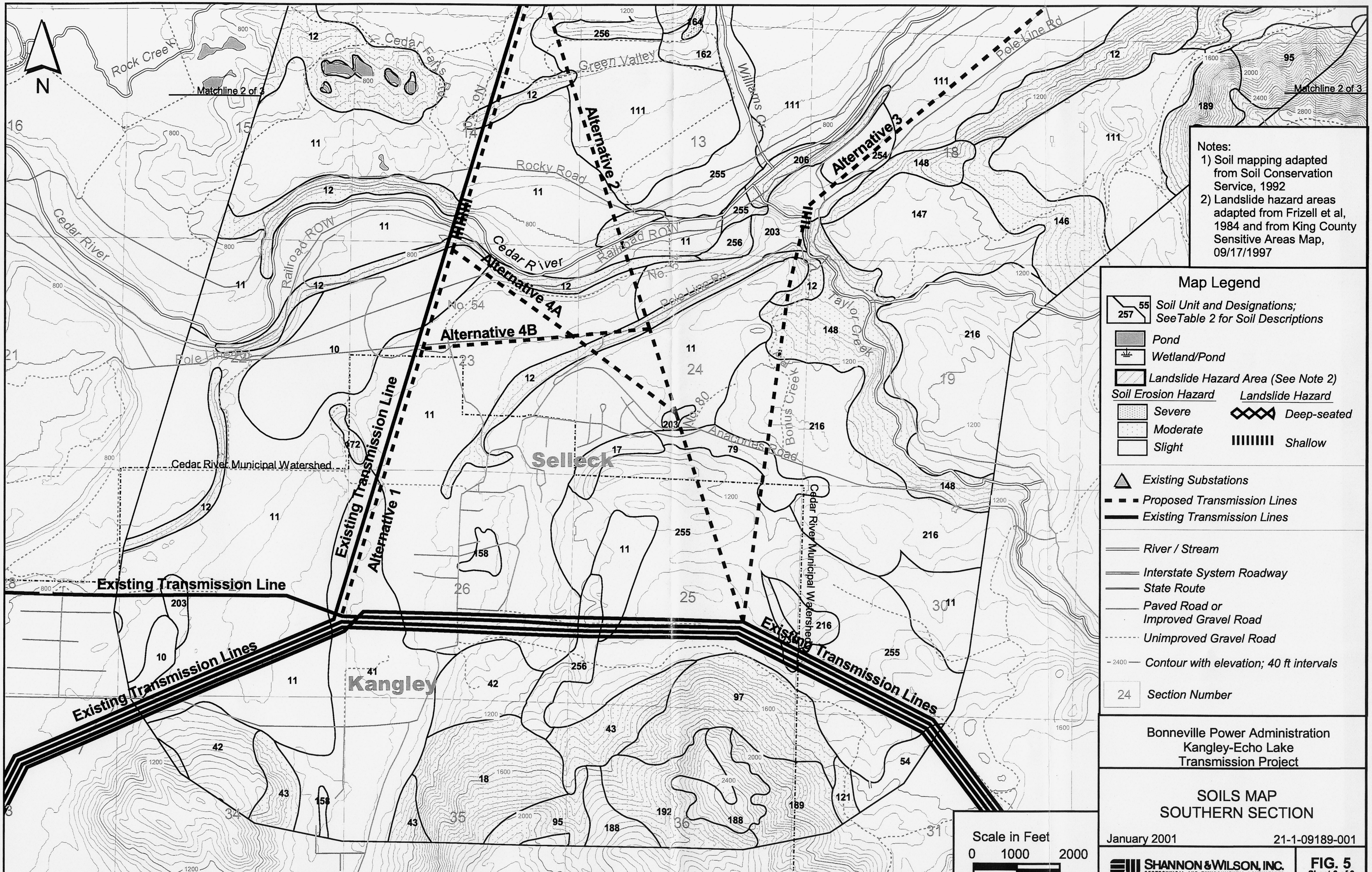


FIG. 5
Sheet 3 of 3

Addition to Appendix U Letter from the National Marine Fisheries Service

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

03 APR -8 AM 6:12

RECEIVED BY BPA ADMINISTRATOR'S
CRC-LOG #: 03-0094
RECEIPT DATE: 4-7-03
DUE DATE:
APP ACTION___

April 3, 2003

Steve Wright, Administrator
Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208-3621

APP ACTION: KE/KEW-4
cc: A-7, D-7, K-7, DC/Wash, L-7, P-6, DM-7, T/Ditt2, LBodi-A/Seattle

Dear ~~Mr. Wright~~ Steve:

This to advise on the proposed Bonneville Power Administration Transmission Line (BPA-Kangley-Echo Lake) across the Cedar River Watershed and the City of Seattle's Cedar River Habitat Conservation Plan. We previously reviewed the proposed Kangley-Echo Lake Transmission Line project and found that the project as originally proposed in July 2001 does not jeopardize the continued existence of salmonids listed under the Endangered Species Act (see our ESA Section 7(a)(2) consultation letters dated January 28 and November 26, 2002). Moreover, we expect that BPA will review any revised action and reinitiate Section 7 consultation as necessary to meet all of its ESA obligations. So long as BPA complies with the terms and conditions of the ESA consultation and implements the project as proposed, we believe the transmission project is compatible with the City of Seattle's Cedar River Watershed Habitat Conservation Plan (HCP).

We view the Kangley-Echo Lake Transmission Line as a Federal project, though a large portion would occur on City of Seattle owned land. The project is proposed and funded by a Federal agency, pursuant to Federal statutory mandates, and BPA owns the property rights to conduct all activities required to construct, operate and maintain the transmission system. Furthermore, we have assured the City that their HCP remains a properly implemented conservation plan even accounting for potential impacts of BPA's proposed transmission line. The City's legal obligations under the HCP are clearly identified in the Implementing Agreement, April 21, 2000. BPA's action, as a non-party to the HCP, does not affect any rights or obligations in the HCP, or its related agreements. Furthermore, the proposed BPA conservation measures, including the permanent protection of approximately 573 acres of adjacent parcels of property, ensure that the effects of the overall action upon HCP-covered anadromous fish species will not adversely affect the purpose or operation of the HCP.

In the event that unauthorized take of a Federally listed species occurs on land in or near the proposed transmission line right of way, and such take is caused by action, or inaction, of BPA's employees, contractors or agents, NOAA Fisheries will consider BPA or its employees, contractors or agents, (not the City of Seattle), liable and responsible for any damages, penalties, or other available remedies, to the full extent allowed by law. In our view, underlying property interest alone is not sufficient to trigger ESA liability. We hope this letter clarifies any concerns you may have regarding our view of the Kangley-Echo Lake Transmission Line project in light of the HCP.

NOAA Fisheries stands ready to work closely with BPA if a revised action leads BPA to reinitiate Section 7 consultation. At the same time, we place a high value on maintaining a close working relationship with the City and want to continue to help the City implement the HCP as an effective conservation tool for ESA. If you have any questions, please call Matt Longenbaugh of my staff at 360-753-7761.

Sincerely,

D. Robert Lohn

D. Robert Lohn
Regional Administrator

cc: Chuck Clarke, Seattle Public Utilities, Director

Appendix Y Drinking Water Regulations

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

SEATTLE
RICHLAND
FAIRBANKS
ANCHORAGE
DENVER
SAINT LOUIS
BOSTON

January 16, 2003

Gene Lynard P - KEC-4
Bonneville Power Administration
905 N.E. 11th Avenue
P.O. Box 3621
Portland, Oregon 97208-3621

RE: DRINKING WATER REGULATIONS, KANGLEY-ECHO LAKE TRANSMISSION LINE ALTERNATIVE ROUTES, KING COUNTY, WASHINGTON

Dear Gene

Per your request, we are providing a summary of drinking water regulations that may affect construction of the Bonneville Power Administration's (BPA's) proposed transmission line alignment. Alignment alternatives cross the City of Seattle's Cedar River Municipal Watershed and both the City of Kent's and the Covington Water District's wellhead protection areas (WHPA). Shannon & Wilson prepared two reports for BPA to use in preparation of their environmental impact statement for this project. These reports are "Bonneville Power Administration Kangley-Echo Lake Transmission Line Project Geology, Soil, Climate and Hydrology Technical Report," dated January 2001, and "Bonneville Power Administration Kangley-Echo Lake Transmission Line Project Geology, Soil, Climate and Hydrology Additional Alternatives Technical Report," dated October 2002. The January 2001 report addressed transmission alignment alternatives 1, 2, 3, 4A, and 4B that traverse through the Cedar River Municipal Watershed. The October 2002 report addressed transmission alignment alternatives A, B, C, and D. Alternatives A and C traverse through the City of Kent's and Covington Water District's WHPA.

The Cedar River Municipal Watershed is an unfiltered source of drinking water for Seattle and several suburban cities. Seattle Public Utilities (SPU) operates this water system. The City of Kent and the Covington Water District share several of the same groundwater sources that supply drinking water to public wells and are developing wellhead protection programs (WHPP) to protect these sources. Although the area around several springs within the WHPA that supply groundwater to the City of Kent are owned by the city, much of the WHPA lies to a large extent outside the Kent city limits. The Covington Water District, which builds and maintains their water distribution infrastructure, does not own significant land area within the WHPA.

BACKGROUND INFORMATION

The Safe Drinking Water Act (SDWA), passed in 1974, and amended in 1986 and 1996, gives the U.S. Environmental Protection Agency (EPA) the authority to set drinking water standards. In most cases, the EPA delegates responsibility for implementing the drinking water standards to the states. Washington is one such state that implements these federal regulations. The EPA has set two categories of drinking water standards, the National Primary Drinking Water Standard and the National Secondary Drinking Water Standard. The primary standards set legally-enforceable levels of specific contaminants that can adversely affect public health. The secondary standards are non-enforceable guidelines that address contaminants that may cause cosmetic or aesthetic effects.

Information reviewed for this study included the EPA webpage (www.epa.gov), the Washington Administrative Code (WAC, www.leg.wa.gov/wac/) and the Revised Code of Washington (RCW, www.leg.wa.gov/rcw/). We also reviewed SPU's Watershed Protection Plan for the Cedar River Watershed, dated October 1999, and the City of Kent's Wellhead Protection Program for Clark, Kent, and Armstrong Springs, dated April 1996. Information for the Covington Water District was obtained from their web site (www.covingtonwater.com) as well as from telephone conversations with district personnel (Mike Amburgey, January 10, 2003) and their engineering consultants (Bill Reynolds, with Hammer, Wade Collier & Livingston, 2003).

The Cedar River Municipal Watershed and both the City of Kent's and the Covington Water District's WHPA are considered Community Group A water systems, defined as a water system that provides service to 15 or more connections to year-round residents for 180 days or more. The Washington State Department of Health (DOH) has jurisdiction over Group A community water systems. Statutory authority for regulation of drinking water systems by the DOH is provided in RCW 43.20.050. The proposed transmission line will require construction and use of access roads, the temporary disturbance of surficial soil during tower installation, and periodic maintenance of vegetation. Protection of groundwater sources for drinking water is regulated by the DOH under WAC 246-290-135, while protection of unfiltered surface water sources is regulated under WAC 246-290-690.

CITY OF KENT-COVINGTON WATER DISTRICT WELLHEAD PROTECTION AREAS

The state regulations require the development of Sanitary Control Areas (SCA) around all drinking water sources. For wells and springs, the minimum diameter of a SCA is 100 feet and 200 feet, respectively. No source of contamination may be constructed, stored, disposed of, or applied within the SCA without the permission of the DOH and the water system purveyor (owner and/or operator of the water system).

Groundwater resources for the City of Kent include the Kent, Clark and Armstrong springs. Spring locations are shown on the attached Figures 1A and 1B (originally presented in the October 2002 report) and are in the vicinity of the Alternative A alignment. Covington Water District wells in the vicinity of Alternative A include two wells at 16818 SE Wax Road (referred to as the Rouse well site) near the Covington substation and Armstrong springs. These wells are currently not producing water for the district (M. Amburgey, January 10, 2003). A field that includes five production wells and one monitoring well occurs at 29025 222nd Place SE, near the Kent springs. Other Covington Water District wells in the vicinity of the Alternative A alignment include six production wells and a monitoring well at the Witte field, located at 26410 Witte Road SE, and two wells at 21765 SE 264th Street. One Covington Water District well is located in the vicinity of the C-1 and C-2 alignments at 27519 SE Kent-Kangley Road. Covington Water District well locations are shown on the attached Figures 1A and 1B. Potential impacts to the Covington Water District WHPA will be the same as those for the City of Kent's WHPA discussed in our October 2002 report.

Because the City of Kent and the Covington Water District have no jurisdiction over much of the WHPA, the WHPP does not list specific requirements for protection of the groundwater resources, but does list recommendations for increased protection, including obtaining Special Area Designations, addressing storm water impacts, and developing spill response plans. The WHPP is required to identify the locations and owners of known and potential groundwater contamination sources within the designated WHPA. Except for uses within the SCA, there are no DOH regulations regarding land use activities specific to the protection of groundwater resources for drinking water supplies. Storm water pollution prevention plans (SWPPP) that include hazardous material spill response plans would be required under EPA's National Pollutant Discharge Elimination System (NPDES). These SWPPPs are regulated by the Washington State Department of Ecology (DOE).

CITY OF SEATTLE CEDAR RIVER WATERSHED

The development and implementation of a Watershed Control Program (WSCP) for unfiltered surface water supplies is required under WAC 246-290-690. These regulations state that the purveyor must prevent water with a turbidity exceeding 5 NTUs (nephelometric turbidity units) from being delivered to consumers. The purveyor shall monitor, limit, and control all facilities and activities in the watershed affecting source quality. The purveyor must demonstrate to the DOH through ownership and/or written agreements control of all human activities that may adversely impact source quality. The WSCP must identify watershed characteristics and activities that may adversely affect source water quality. The DOH can require additional water quality monitoring and conduct on-site inspections to assess watershed control. The WSCP is to be updated at a minimum of every six years. Annual reports are to be provided to the DOH to identify special concerns in the watershed and how they are being handled, identify activities in the watershed, and project adverse activities expected to occur in the watershed and measures to address them.

The Cedar River WSCP lists potential adverse activities and whether they are present within the watershed. Timber management, including road construction and fire prevention, is listed as an adverse activity and as present within the watershed. This activity most closely resembles construction of the transmission line, which would involve clearing a right-of-way and construction and use of roads.

The following regulations are listed in the Cedar River WSCP and specifically address measures to control activities that could adversely impact the water quality.

Portable sanitary facilities must be installed at work sites.

- Use of heavy equipment on roads can be shut down during wet weather periods to reduce sedimentation.
- Hazardous material spill cleanup plans are required. While only DOE needs to approve plans for spills that would not affect a drinking water source, both DOE and DOH must approve those plans that could.
- A written water quality protection plan approved by SPU must be in place prior to start of construction in which spills from equipment or storage containers may occur.
- Fire safety procedures must be followed.
- Monitoring the effects of land use activities could be required.

As purveyor of the Cedar River Municipal Watershed, and therefore, legally required to protect the drinking water resources, SPU has a generally broad latitude in regulating the how, where, and when of activities within the watershed. For instance, prior to conducting recent subsurface soil explorations, SPU required BPA to steam clean all drilling and support equipment to remove any noxious weed seeds and other potential contaminants, prior to using this equipment in the Cedar River Municipal Watershed. Similar procedures may be required of the construction equipment, should the line be constructed in the Watershed

If we can be of further assistance, please call Chris Robertson (206 695-6763) or Jeff Laird (206 695-6892).

Sincerely,

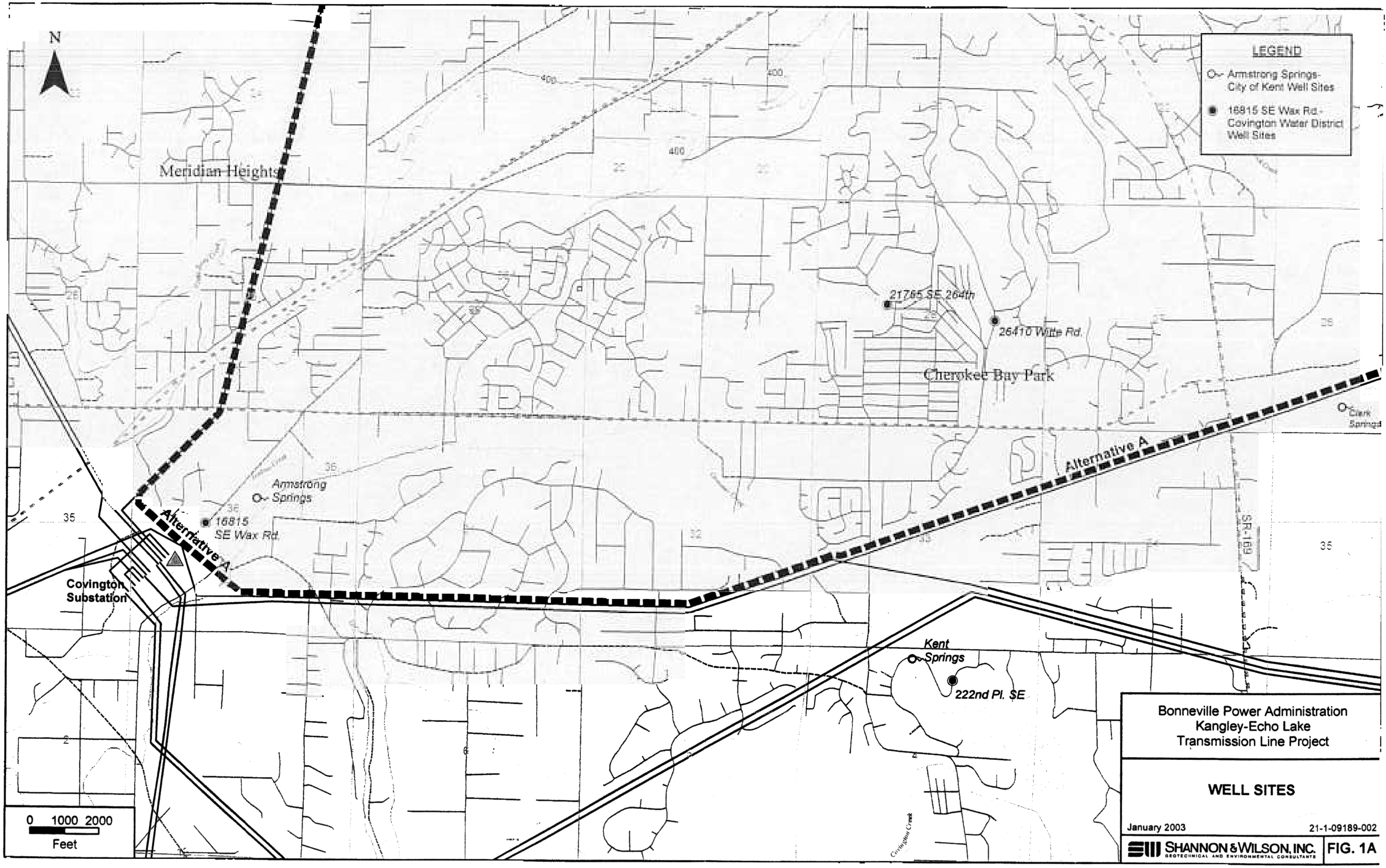
SHANNON & WILSON, INC.

Jeffrey R. Laird

Jeffrey R. Laird, C.E.G.
Senior Principal Engineering Geologist

JRL:CAR/jrl

Enclosures: Figure 1A – Well Sites
Figure 1B – Well Sites



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

WELL SITES

January 2003

21-1-09189-002

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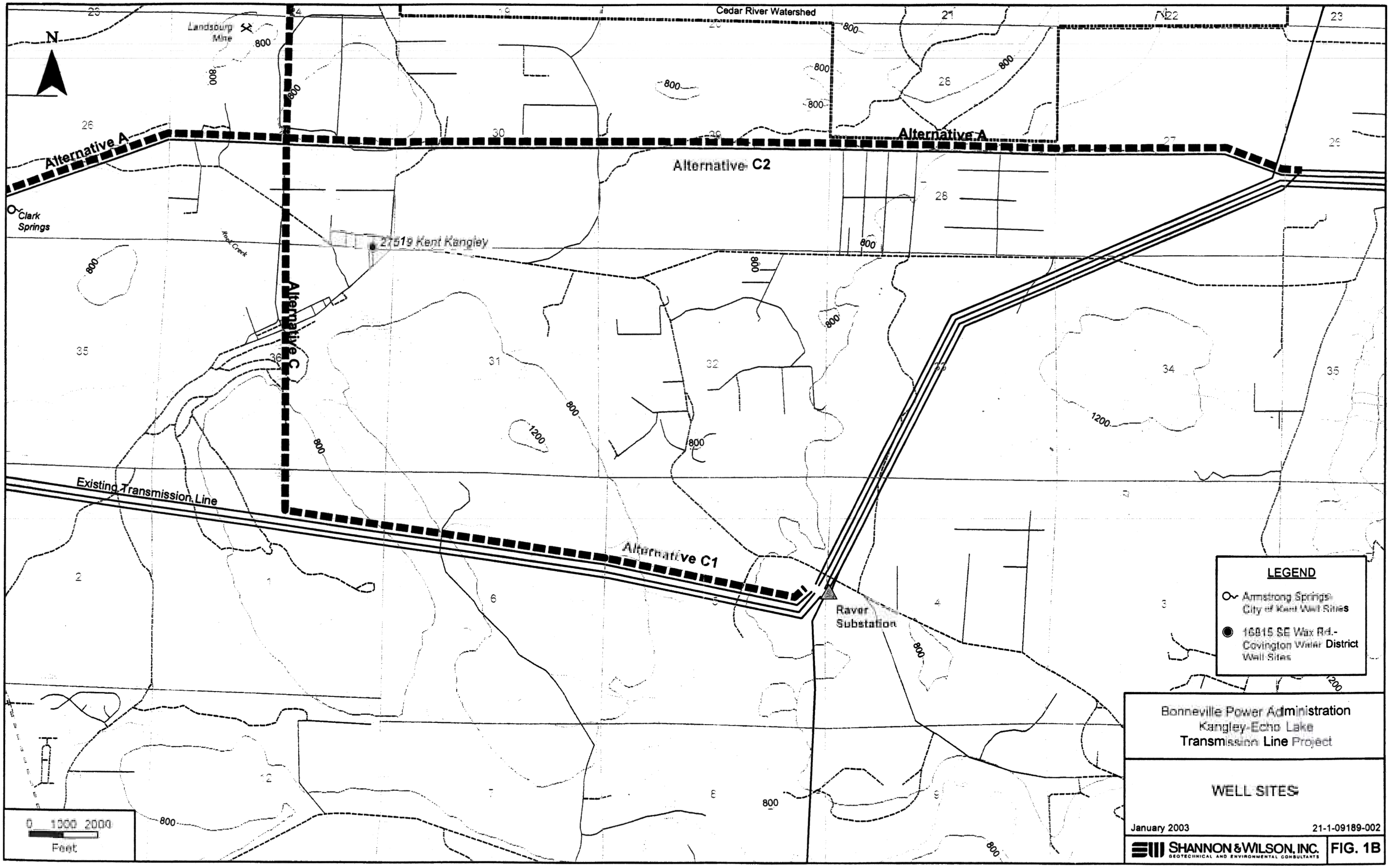
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1A



N
Cedar River Watershed
Landsburg Mine
Clark Springs
Rock Creek
27519 Kent Kangley
Alternative A
Alternative C
Alternative C1
Alternative C2
Existing Transmission Line
Raver Substation
LEGEND
Armstrong Springs City of Kent Well Sites
16815 SE Wax Rd.- Covington Water District Well Sites
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
WELL SITES
January 2003
21-1-09189-002
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FIG. 1B

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ANCHORAGE
DENVER
SAINT LOUIS
BOSTON

March 3, 2003

Bonneville Power Administration
905 N.E. 11th Avenue
P.O. Box 3621
Portland, Oregon 97208-3621

RE: RESPONSE TO COMMENTS, FOOTHILLS WATER ASSOCIATION, BONNEVILLE POWER ADMINISTRATION KANGLEY - ECHO LAKE PROJECT, KING COUNTY, WASHINGTON

Dear Gene:

This letter provides our response to comments from members of the Foothills Water Association (FWA). From the comments, we understand the FWA owns and operates a recently constructed drinking water system that serves 74 homes in the communities of Kangley and Selleck, located on the south side of the Cedar River. The system relies on groundwater supplies and includes two wells, a 20,000-gallon tank, a pump station, and water mains. The system replaces several older water systems that relied on surface water supplies. From our discussions with Jim Nilson of the Washington State Department of Health (DOH) and with Rick Kenney of FWA on February 26, 2003, we understand that one well was drilled in 1993 to a depth of 140 feet. The water-bearing zone was thought to be between 120 and 140 feet. The other well was drilled in 1995 to a depth of 220 feet. The casing in this well was perforated for water production between 150 and 172 feet deep.

Currently, the Bonneville Power Administration's (BPA's) transmission line easement that includes the Schultz-Raver No. 2 500-kV transmission line traverses east-west across the south end of the FWA service area. The Raver-Echo Lake 500-kV transmission line extends to the north across the northwest corner of the FWA service area. The FWA's well field is located about one block east of the current Raver-Echo Lake transmission line easement and abuts the south boundary of the Cedar River Watershed (see attached site plan).

400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303
SEATTLE, WASHINGTON 98103
206•632•8020 FAX 206•695•6777
TDD: 1•800•833•6388

The Alternative 1 route would tap into the Schultz-Raver No. 2 500-kV transmission line just west of Kangley and extend north along the east side of the existing Raver-Echo Lake transmission line. Alternative 1 will extend about 3,800 feet through the FWA service area and will require the acquisition of additional easement (see attached site plan). Alternative A would tap into the Schultz-Raver No. 2 500-kV transmission line just west of Kangley, near the west boundary of the FWA service area, and extend west in an existing transmission line right-of-way (ROW) just north of and parallel to the existing Covington-Columbia No. 3 230-kV transmission line (see attached site plan).

This FWA water system is a Community Group A system, defined as a water system that provides service to 15 or more connections to year-round residents for 180 days or more. The DOH has jurisdiction over Group A community water systems. Washington State regulations require a Sanitary Control Area (SCA) of 100 feet diameter around wells supplying groundwater for drinking. It appears that either Alternative 1 or A will be outside of this SCA.

The proposed transmission line will require construction and use of access roads, the temporary disturbance of surficial soil during tower installation, and periodic maintenance of vegetation. If Alternative 1 or A is constructed, a relatively small portion of the existing area that the FWA currently serves will be impacted. These impacts will be limited in intensity and area and will be primarily temporary.

Potential impacts to the groundwater supplies are discussed in our January 2001 and October 2002 technical reports. These impacts would be the same for the FWA system as for other groundwater sources for drinking water. It is unlikely that the FWA's groundwater source will be impacted by the construction or operation of the transmission line; however, spills of fuel oil, lubricants, or other hazardous materials could occur. A Stormwater Pollution Prevention Plan that will include a hazardous materials spill response plan will be required to be in place during construction. These plans typically require vehicle fueling and storage, and storage of hazardous materials, to occur away from groundwater protection areas. This plan is intended to facilitate a rapid, appropriate response to reduce or eliminate potential impacts in the unlikely event that a hazardous material spill occurs. State regulations regarding drinking water supplies have been summarized in a letter to BPA dated January 16, 2003.

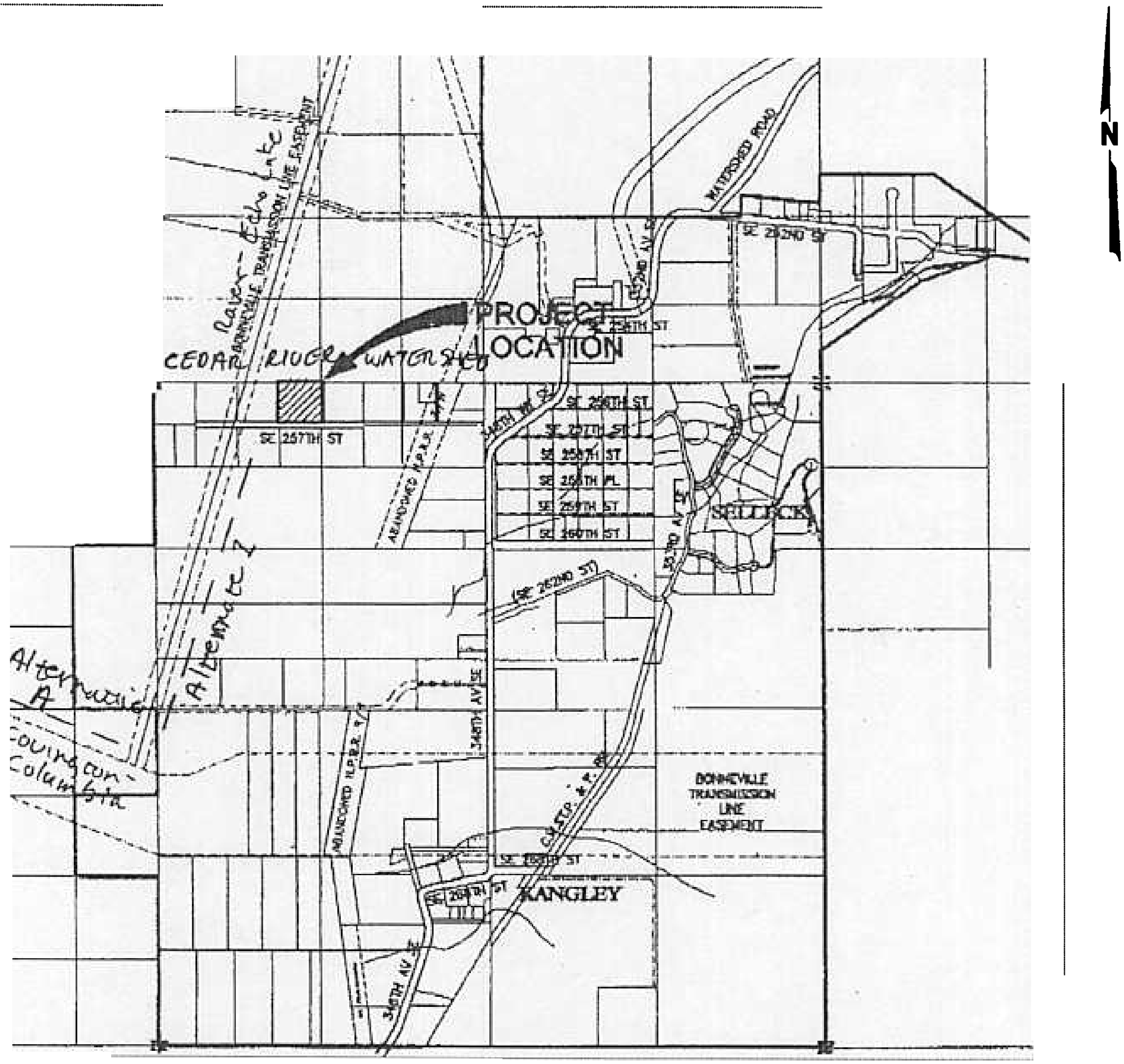
If we can be of further assistance, please call Chris Robertson (206 695-6763) or Jeff Laird (206 695-6892).

Sincerely,

SHANNON & WILSON, INC.

Jeffrey R. Laird, C E.G
Senior Principal Engineering Geologist

JRL:CAR/jrl



NOTE

Site plan provided by Foothills Water Association.

Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

FOOTHILLS WATER ASSOCIATION SITE PLAN

May 2003 | 21-1-09189-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1

Appendix Z Updated EMF Information

GRAND COULEE– BELL 500-kV TRANSMISSION LINE PROJECT

APPENDIX B-2:

ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS

June, 2002

Prepared by

Exponent™

for

T. Dan Bracken, Inc.

and

Bonneville Power Administration

Table of Contents

APPENDIX B-2: ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS

1.0 Introduction

Over the last 20 years, research has been conducted in the United States and around the world to examine whether exposures to electric and magnetic fields (EMF) at 50/60 Hertz (Hz) have health or environmental effects. EMF are produced by both natural and man-made sources that surround us in our daily lives. They are found throughout nature and in our own bodies, and the earth itself produces a static (0 Hz) magnetic field—it is this field that is used for compass navigation.

By contrast, electricity provided to homes and offices produces EMF that change direction and intensity 60 times, or cycles, per second—a frequency of 60 Hz. Fields at this frequency differ significantly from fields at the higher frequencies characteristic of radio and television signals, microwaves from ovens, cellular phones, and radar (which can have frequencies up to billions of Hz). Man-made EMF are found wherever electricity is generated, delivered, or used. Power lines, wiring in homes, workplace equipment, electrical appliances, and motors produce EMF.

One of the most important characteristics of electric and magnetic fields is that their strength diminishes as a person moves away from the source. This effect is similar to the diminishment of heat from a candle or campfire as a person walks away. However, electric fields and magnetic fields have different characteristics. For instance, ordinary objects do not block magnetic fields, but special materials and techniques can provide shielding. In contrast, such objects, especially those that can conduct electricity, can reduce the electric fields. For example, a typical house may block up to 90% of the electric field from outside sources. Because of this characteristic, exposure to electric fields is more difficult to calculate than exposure to magnetic fields. Magnetic fields have been more widely studied in the last 20 years than electric fields, in part because structures and vegetation reduce indoor electric-field exposures.

Among the large number of studies conducted are a number of epidemiology studies that suggested a link with childhood leukemia for some types of exposures, as well as a number of other epidemiology studies that did not. The research also included lifetime animal studies, which showed no evidence of adverse health effects. Comprehensive reviews of the research conducted by governmental and scientific agencies in the U.S. and in the United Kingdom (UK) have examined the research, and have found no basis for imposing restrictions on exposures (NIEHS, 1999; IEE, 2000; IARC, 2002).

The Bonneville Power Administration (BPA) asked Exponent to update BPA on research on EMF and health and environmental effects in relation to exposures that might occur near the proposed Grand Coulee – Bell Transmission Line Project. This update concentrates on recent major research studies to explain how they contribute to the assessment of effects of EMF on health (Section 2). The focus is on both epidemiologic and laboratory research, because these research approaches provide different and complementary information for determining whether an environmental exposure could affect human health. Section 3, Ecological Research, reviews studies of potential effects of EMF on plants and animals in the natural environment. This update includes those studies of effects from residential or environmental exposures to EMF that became available through May 2002.

2.0 Health

2.1 The NIEHS Report and Research Program

In 1998, the National Institute of Environmental Health Sciences (NIEHS) completed a comprehensive review of the scientific research on health effects of EMF. The NIEHS had been managing a research program that Congress funded in 1992 in response to questions regarding exposure to EMF from power sources. The program was known as the RAPID Program (Research and Public Information Dissemination Program). The NIEHS convened a panel of scientists (the "Working Group") to review and evaluate the RAPID Program research and other research. Their report, *Assessment of Health Effects from Exposure to Power-line Frequency Electric and Magnetic Fields,* was completed in July 1998 (NIEHS, 1998).

The director of the NIEHS prepared a health-risk assessment of EMF and submitted his report to Congress in June 1999 (NIEHS, 1999). Experts at NIEHS, who had considered a previous Working Group report, reports from four technical workshops, and research that became available after June 1998, concluded as follows:

> The scientific evidence suggesting that ELF-EMF [extremely low frequency-electric and magnetic field] exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. . . . In contrast, the mechanistic studies and animal toxicology literature fail to demonstrate any consistent pattern. . . . No indication of increased leukemias in experimental animals has been observed. . . . The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiology findings. . . . The NIEHS does not believe that other cancers or other non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern (NIEHS, 1999: 9-10).

Although the results of the RAPID research are described in some detail in the 1998 report, many of the studies had not been published in the peer-reviewed literature. Recognizing the need to have these results reviewed and considered for publication, the NIEHS arranged for this research to be published in a peer reviewed special edition of the journal *Radiation Research* (Radiation Research, 153[5], 2000).[1]

2.2 Research Related to Cancer

This update includes studies of residential or occupational exposures to EMF and leukemia that became available through May 2002, including several epidemiology studies of childhood cancer and meta-analyses. The California Department of Health Services (CDHS) conducted a workshop in 1999 to discuss epidemiologic research on EMF and health. The reports presented at this workshop were published in January 2001 as a supplement to the journal, *Bioelectromagnetics*. Many of the papers were technical discussions of methodology issues in epidemiologic studies of EMF, including discussions of how to better understand the conflicting results reported in previous studies (Neutra and Del Pizzo, 2001). For example, one study evaluates the extent to which systematic errors (known in epidemiology as *selection bias* or *information bias*) occurred in EMF studies, and, if those errors occurred, whether the effect on results could be evaluated (Wartenberg, 2001a). Other researchers discuss epidemiologic approaches to study how possible confounding factors, such as the age and type of home and traffic

---

[1] See, for instance, the articles cited in the **List of References** under first author Balcer-Kubiczek, Boorman, Loberg, or Ryan.

density, might affect the interpretation of studies of EMF and childhood cancer (Langholz, 2001; Reynolds et al., 2001).

For this update, we reviewed epidemiology and laboratory studies of cancer and reproduction. Several of the studies are "meta-analyses," an approach that incorporates statistical methods to analyze differences among studies and aggregate the results of smaller studies. The sections below include a review of meta-analyses of the studies of childhood leukemia, and a meta-analysis of studies of breast cancer in adults (Erren, 2001).

2.2.1 Epidemiology Studies of Children

The question of the relationship between power lines and childhood cancer has been based on the assumption that the relevant exposure associated with power lines is the magnetic field, rather than the electric field. This assumption rests on the fact that electric fields are shielded from the interior of homes (where people spend the vast majority of their time) by walls and vegetation, while magnetic fields are not. The magnetic field in the vicinity of a power line results from the flow of current; higher currents result in higher levels of magnetic fields.

Epidemiologic studies report results in the form of statistical associations. The term "statistical association" is used to describe the tendency of two things to be linked or to vary in the same way, such as level of exposure and occurrence of disease. However, statistical associations are not automatically an indication of cause and effect, because the interpretation of numerical information depends on the context, including (for example) the nature of what is being studied, the source of the data, how the data were collected, and the size of the study. The larger studies and more powerful studies of EMF have not reported convincing statistical associations between power lines and childhood leukemia (e.g., Linet et al., 1997; McBride et al., 1999; UKCCS, 1999). Despite the larger sample size, these studies usually had a limited number of cases exposed over 2 or 3 milligauss (mG).

Epidemiology Studies

The following discussion briefly describes major studies.

- A study from Germany included 514 children with leukemia and 1,301 control children (Schuz et al., 2001). Measurements of magnetic-field intensity (50 Hz) were taken for 24 hours in each child's bedroom. The results were calculated separately for daytime or nighttime levels in the bedroom, rather than for a child's overall 24-hour exposure. The authors report an association with leukemia for mean daytime magnetic-field exposures that might have been due to chance. They reported an association between mean nighttime magnetic-field levels and leukemia for the highest exposed group (4 mG or higher; 9 cases). The assessment of exposure by mean field levels in the bedroom did not link magnetic-field levels to any specific source. The authors note in their conclusions that " . . . fewer than one-third of all stronger magnetic fields were caused by high-voltage powerlines . . . . " (Schuz et al., 2001:734).

  Several aspects of the study detract from the validity of the results: the estimate included a broad margin of error because only a small number of cases were exposed at the higher levels, and many eligible cases and controls did not participate. If the cases and controls were not sampled from similar populations, differences in their exposures could be biased. Another concern is that these magnetic-field measurements were taken in 1997, long after the relevant exposure period for cases diagnosed in 1990-1994. Magnetic-field levels might have changed over time, as electricity usage changed.

- A study from British Columbia, Canada, included 462 children who had been diagnosed with leukemia and an equal number of children without leukemia, for comparison (McBride et al., 1999). Magnetic-field exposure was assessed for each of the children in several ways: personal monitors were worn in a backpack for 48 hours, a monitor took measurements in the bedroom for

24 hours, the wiring outside the house was rated by potential exposure level (wire codes), and measurements were taken around the outside perimeter of the homes. (Wire codes are a method of estimating relative exposure intensity based on the configuration of the power lines.) Regardless of the method used to estimate magnetic-field exposure, the magnetic-field exposure of children who had leukemia was not greater than that of the children in the comparison group.

- A study conducted in Ontario, Canada reported on the magnetic-field exposure of a smaller group of children than that in other recent studies (Green et al., 1999a). No increased risk estimates were found with the average magnetic fields in the bedroom or the interior, or with any of the three methods of estimating exposure from wire-configuration codes. A still smaller group of 88 children with leukemia and children who served as controls wore personal monitors to measure magnetic fields (Green et al., 1999b). Associations with magnetic fields were reported in some of the analyses, but most of the risk estimates had a broad margin of error, and major methodological problems in the study preclude any clear interpretation of the findings.
- The United Kingdom Childhood Cancer Study, the largest study to date, included a total of 1073 childhood leukemia cases (UKCCS, 1999). Exposure was assessed by spot measurements in the home (bedroom and family room) and school, and summarized by averaging these over time. No evidence was found to support the idea of an increased risk of leukemia from exposures to magnetic fields inside or outside of the home.
- The UKCCS investigators had obtained magnetic-field measurements on only a portion of the childhood cancer cases in their study (UKCCS, 1999). To obtain additional information, they used a method to assess exposure to magnetic fields without entering homes; they were thus able to analyze 1331 child leukemia cases (UKCCS, 2000). For these children, they measured distances to power lines and substations. This information was used to calculate the magnetic field from these external field sources, based on power-line characteristics related to production of magnetic fields. The results of the second UKCCS study showed no evidence for an association with leukemia for magnetic fields calculated to be between 1 mG and 2 mG, 2 mG and 4 mG, or 4 mG or greater at the residence, in contrast to the weak association reported for measured fields of 4 mG or greater in the first report (UKCCS, 1999).

Researchers have proposed that the associations that are sometimes reported between childhood leukemia and power lines might be due to other factors that can confound the analysis (other risk factors for disease that may distort the analysis). One example is heavy traffic, which may occur near power lines and can increase the levels of potentially carcinogenic chemicals in the area. Earlier studies had reported associations between traffic density and childhood cancer (Savitz et al., 1988). If power lines were more common in areas that had higher traffic density, then the increased air pollution might explain an association between power lines and childhood cancer. However, more recent studies do not support this possibility. Reynolds et al. (2001) found no evidence of an association with traffic density in a study of 90 cases of childhood leukemia. In a larger study that included 986 cases of childhood leukemia, no association was found with high traffic-density exposure during pregnancy or childhood (Raaschou-Nielsen et al., 2001).

Meta-analyses of Studies of Leukemia

Recently, researchers re-analyzed the data from previous epidemiology studies of magnetic fields and childhood leukemia (Ahlbom et al., 2000; Greenland et al., 2000). The researchers pooled the data on individuals from each of the studies, in effect creating a study with a larger number of subjects and therefore with greater statistical power than any single study. A pooled analysis is preferable to other types of meta-analyses in which the results from several studies are combined from grouped data obtained from the published studies. These analyses focused on studies that assessed exposure to magnetic fields using 24-hour measurements or calculations based on the characteristics of the power lines and current load. Both Ahlbom et al. and Greenland et al. used exposure categories of <1 mG (<0.1 microtesla [μT]) as a reference category. The statistical results of these analyses can be summarized as follows:

- The pooled analyses provided no indication that wire codes are more strongly associated with leukemia than measured fields.
- Pooling these data corroborates an absence of an association between childhood leukemia and magnetic fields for exposures below 3 mG (0.3 μT).
- Pooling these data results in a statistical association with leukemia for exposures greater than 3-4 mG (0.3 or 0.4 μT).

The authors are appropriately cautious in the interpretation of their analyses, and they identify the limitations in their evaluation of the original studies. Limitations include sparse data (few cases) to adequately characterize a relationship between magnetic fields and leukemia, uncertainties related to pooling different magnetic-field measures without evidence that all of the measures are comparable, and the incomplete and limited data on important confounders such as housing type and traffic density. Magnetic fields above 3 mG (0.3 μT) in residences are estimated to be rather rare, about 3% in the U.S. (Zaffanella, 1993).

A meta-analysis of the data from epidemiologic studies of childhood leukemia studies was presented at the California Workshop and recently published (Wartenberg, 2001b). This meta-analysis did not have the advantage of obtaining and pooling the data on all of the individuals in the studies, unlike those published before it (Ahlbom et al., 2000; Greenland et al., 2000). Instead of using individual data, Wartenberg (2001b) used an approach that extracted the published results, reported as grouped data from several published studies. He used 19 studies overall, after excluding 7 studies that had insufficient data on individuals or deficiencies in the exposure assessment data. He reported a weak association for a) “proximity to electrical facilities” based on wire codes or distance, and b) magnetic-field level over 2 mG, based on either calculations from wiring characteristics or on spot magnetic-field measurements. The results show more cases than controls exposed to measured or calculated fields above 2 mG. The author concludes that the analysis supports an association, although the size of the effect is small to moderate, but also notes “limitations due to design, confounding, and other biases may suggest alternative interpretations” (Wartenberg, 2001b:S-100).

The results of this meta-analysis are not directly comparable to previous ones regarding fields of 3 or 4 mG because the analysis was not based on individual data. The comparison of grouped data used different exposure cut points for the analysis and different criteria for the comparison group. None of these three analyses (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg, 2001b) included the results of the latest UK analysis (UKCCS, 2000) of 1331 child leukemia cases based on calculated fields, which found no association between EMF and childhood leukemia or other cancers, regardless of the exposure level.

2.2.2 Epidemiology Studies of Adults

Studies of adults with certain types of cancer, such as brain cancer, breast cancer, or leukemia, have reported associations with exposure to magnetic fields at residences, but results have not been consistent across studies. Contradictory results among studies argue against a conclusion that the association reflects a cause-and-effect relationship. In their assessments of risk, scientists give most weight to studies that include more people, obtain more detailed and individual exposure assessments, and/or include people who have higher exposures.

Brain Cancer

A study of 492 adult cases of brain cancer in California included measurements of magnetic fields taken in the home and at the front door, and considered the types of power-line wiring (Wrensch et al., 1999).

The authors report no evidence of increased risk with higher exposures, no association with type of power line, and no link with levels measured at the front door.

Breast Cancer

A number of recent studies of breast cancer focused on electric blankets as a source of high exposure. Electric blankets are assumed to be one of the strongest sources of EMF exposure in the home. Three studies of electric-blanket use found no evidence that long-term use increased the risk of breast cancer. Women who developed breast cancer reported no difference in total use of electric blankets, use in recent years, or use many years in the past:

- Gammon et al. (1998) reported that, even for those who kept the blanket on most of the time, no increase in risk was found for those who had longer duration of use (measured in months).
- A study of 608 breast cancer cases found no evidence of increased use of electric blankets or other home appliances in cases compared to controls, and no indication of increasing risk with a longer time of use (Zheng et al., 2000).
- In a cohort of over 120,000 female nurses, data were obtained on known risk factors for breast cancer as well as electric-blanket use (Laden et al., 2000). For a large subset of this group, the questions about exposure were asked before the disease occurred, a step taken to eliminate bias in recalling exposure. No associations with electric-blanket use were found.

Erren (2001) reported the results of a meta-analysis of the studies of breast cancer, in which the results of 24 different studies in women were statistically aggregated. When the results of all 24 studies, including studies of workplace exposures, were pooled, the estimate indicated an association between EMF and a small excess breast cancer risk. The pooled results for exposure to EMF in the vicinity of *electrical facilities such as power lines* did not show an association with breast cancer, nor did the results for exposure to EMF from appliance use. However, the meta-analysis also showed a lack of consistency among the results of the individual studies, a broad variation in the designs, and a wide range of methods used to assess exposure. No adjustments were made to the data to give increased weight to studies based on more comprehensive exposure assessments. The author also noted that the weak statistical association might be an artifact (a result of chance or unforeseen error) rather than an indication of a cause-and-effect relationship (Erren, 2001).

2.2.3 Laboratory Studies of EMF

Laboratory studies complement epidemiologic studies of people because the effects of heredity, diet, and other health-related exposures of animals can be better controlled or eliminated. The assessment of EMF and health, as for any other exposure, includes chronic, long-term studies in animals (*in vivo* studies) and studies of changes in genes or other cellular processes observed in isolated cells and tissues in the laboratory (*in vitro*).

Although the results of the RAPID Program were described in some detail in the NIEHS reports (NIEHS, 1998), many of the studies had not been published in the peer-reviewed literature. The RAPID research program included studies of four biological effects, each of which had previously been observed in only one laboratory. These effects are as follows: effects on gene expression, increased intracellular calcium in a human cell line, proliferation of cell colonies on agar, and increased activity of the enzyme ornithine decarboylase (ODC). Some scientists have suggested that these biological responses are signs of possible adverse health effects of EMF. It is standard scientific procedure to attempt to replicate results in other laboratories, because artifacts and investigator error can occur in scientific investigations. Replications, often using more experiments or more rigorous protocols, help to ensure objectivity and validity. Attempts at replication can substantiate and strengthen an observation, or they may discover the underlying reason for the observed response.

Studies in the RAPID program reported no consistent biological effects of EMF exposure on gene expression, intracellular calcium concentration, growth of cell colonies on agar, or ODC activity (Boorman et al., 2000b). For example, Balcer-Kubiczek et al. (2000) and Loberg et al. (2000) studied the expression of hundreds of cancer-related genes in human mammary or leukemia cell lines. They found no increase in gene expression with increased intensity of magnetic fields. To test the experimental procedure, they used X-rays and treatments known to affect the genes (chemical or heat). These are known as positive controls and, as expected, caused gene expression in exposed cells.

Scientists have concluded that the combined animal bioassay results provide no evidence that magnetic fields cause, enhance, or promote the development of leukemia and lymphoma, or mammary cancer (e.g., Boorman et al., 1999; McCormick et al., 1999; Boorman et al., 2000 a, b; Anderson et al., 2001).

2.2.4 Summary Regarding Cancer

Epidemiology studies do not support the idea that EMF from power lines increase the risk of cancers in adults. The latest epidemiologic studies of childhood cancer, considered in the context of the other data, provide no persuasive evidence that leukemia in children is causally associated with magnetic fields measured at the home, calculated magnetic fields based on distance and current loading, or wire codes. Recent meta-analyses reported no association between childhood cancer and magnetic fields below 2 or 3 mG. Although some association was reported for fields above this level, fields at most residences are likely to be below 3 or 4 mG. The authors of each of these analyses list several biases and problems that render the data inconclusive and prevent resolution of the inconsistencies in the epidemiologic data. For this reason, laboratory studies can provide important complementary information. Large, well-conducted animal studies, and studies of initiation and promotion, provide no basis to conclude that EMF increases leukemia, lymphoma, breast, brain, or any other type of cancer.

2.3 Research Related to Reproduction

Several epidemiology studies have examined effects on pregnancy, including miscarriages[2] in relation to exposures to magnetic fields. Previous epidemiologic studies reported no association with birth weight or fetal growth retardation after exposure to sources of relatively strong magnetic fields, such as electric blankets, or sources of typically weaker magnetic fields such as power lines (Bracken et al., 1995; Belanger et al., 1998; Lee et al., 2000).

- Belanger et al. provided results of a prospective study in 1998. They assessed the magnetic field exposure of 2967 women during their pregnancy in two different ways. Exposure to magnetic fields from electric bed-heating (electric blankets and water beds), sources of relatively strong magnetic fields, was estimated from the women's responses in an interview. In general, electric bed-heating results in higher magnetic field exposures than those from residential fields. Wire codes were assessed for each woman to estimate the contribution, to residential fields, of transmission and distribution lines within 150 feet of house. No evidence of an association between miscarriage and exposure to magnetic fields from living in a residence with "high wire code," or from using electric blankets or a waterbed around the time of conception or during pregnancy (at time of interview) was found. There was no indication of an increased risk with daily exposure, or longer hours, or using the electric bed at the high setting.
- Another study also focused on exposures from electric bed heating (electric blankets, heated waterbeds and mattress pads (Lee et al., 2000). The researchers assessed the women's exposure prior to the birth and included information to control for potential confounding factors. This study had a large number of cases and high participation rates. Miscarriage rates were lower among users of electric bed heating.

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[2] The medical term for miscarriage is spontaneous abortion.

- The data collected in the large, prospective, epidemiology study by Belanger et al. had been analyzed previously for other endpoints. The results of this analysis showed no evidence of reduced birth weight in the infants, or slower fetal growth after exposure to sources of relatively strong magnetic fields, such as electric blankets, or sources of typically weaker magnetic fields such as power lines (Bracken et al., 1995).

Two recent studies of EMF and miscarriage reported a positive association between miscarriage and exposure to high maximum, or instantaneous, peak magnetic fields (Li et al., 2002; Lee et al., 2002). However, no associations were found with higher average magnetic field levels during the day, the typical way of assessing exposure. In these studies women wore magnetic-field monitors for a 24-hour period to assess exposure. Magnetic field levels similar to the peak levels are routinely found near electric devices such as hairdryers, photocopy machines, electric tools, shavers; in or near electric trains; and under some types of power lines. Neither study found that miscarriage was associated with residential wiring codes, another method presumed to identify higher magnetic fields from power lines. There are several possible issues to be considered in assessing whether these statistical associations with the maximum, or peak, exposure during the day are due to cause-and-effect. First, despite years of research, there is no biological basis to indicate that EMF increases the risk of miscarriage. Second, the studies include possible biases. For example, each of the studies had a low response rate, which means that the study groups may not be comparable because those who participate may differ from those who decline (selection bias). Third, these studies found no association with higher daily average exposure, that is, the average of the measurements recorded throughout the day.

Studies of laboratory animals exposed to pure 60-Hz fields have shown no increase in birth defects, no multigenerational effects, and no changes that would indicate an increase in miscarriage or loss of fertility (e.g., Ryan et al., 1999; Ryan et al., 2000). Exposed and unexposed litters were no different in the amount of fetal loss and the number and type of birth defects, indicating no reproductive effect of EMF.

In summary, the recent evidence from epidemiology and laboratory studies do not support the hypothesis that exposure to power-frequency EMF has an adverse effect on reproduction, pregnancy, or growth and development of the embryo. The results of these recent studies are not sufficiently persuasive to change the conclusions of the NIEHS.

2.4 Implanted Medical Devices and EMF

Advances in technology have led to the development of more medical devices that can be implanted to maintain or enhance organ function. Of these devices, most concern has focused on potential interference with cardiac pacemakers and defibrillators. A cardiac pacemaker monitors the electrical activity of the heart. If the heart fails to beat, the pacemaker administers a small stimulus to trigger the “missing” beats. An implanted cardiac defibrillator (ICD) similarly monitors the electrical activity of the heart but is designed to block disorganized contractions of the heart (arrhythmias) by administering a strong electrical shock to restore normal heart rhythms. Exposure to electric and magnetic fields could affect the function of these devices if induced signals on sensing leads are interpreted as natural cardiac activity (e.g., Griffin, 1986; CCOHS, 1988; Barold et al., 1991). However, the opportunities for exposure and interference from power lines are lower than for contact with ordinary household appliances.

Although scientific studies report that exposure to power-frequency electric and magnetic fields have not resulted in adverse responses in patients with pacemakers, the possibility cannot be completely ruled out. In order to reduce potential effects of environmental exposure to electrical and magnetic fields, the Center for Devices and Radiological Health of the U.S. Food and Drug Administration (FDA) has developed guidelines for both the development of pacemakers and the design of new electrical devices to minimize susceptibility to electrical interference from any source. Pacemakers today are designed to filter out electrical stimuli from sources other than the heart, e.g., muscles of the chest, currents encountered from touching household appliances, or currents induced by electric or magnetic fields. Used in both temporary and permanent pacemakers, these electrical filters increase the pacemaker's ability to distinguish extraneous signals from legitimate cardiac signals (Toivonen et al., 1991). Most circuitry of pacemakers is encapsulated by titanium metal, which insulates the device by shielding the pacemaker's pulse generator from electric fields. Some may also be programmed to automatically pace the heart if interference from electric and magnetic fields is detected. This supports cardiac function and allows the subject to feel the pacing and move away from the source.

Due to recent design improvements, many pacemakers in use would not be particularly susceptible to low-intensity electrical fields. There remains a very small possibility that some pacemakers, particularly those of older designs, and with single-lead electrodes, may sense potentials induced on the electrodes and leads of the pacemaker and provide unnecessary stimulation to the heart. In persons wearing some types or brands of implanted cardiac pacemakers, the pacing of the heart might be affected by electric fields at field intensities above about 2 kV/m. The sensitivity of ICD's to external 60-Hz fields has not been studied, but might be expected to be somewhat lower than that for pacemakers. The American Conference of Governmental Industrial Hygienists (ACGIH, 1999) recommends that routine occupational exposure of persons with cardiac pacemaker and similar medical electronic devices should not exceed 1 kV/m and 1000 mG (0.1 mT).

2.5 Recent Reviews by Scientific Advisory Groups

Reviews of the scientific research regarding EMF and health by the Health Council of the Netherlands (HCN) were published in 2000 and updated in May 2001. The NRPB Advisory Group on Non-Ionising Radiation (AGNIR) published the most recent review in 2001. That review includes research published in 2000, and includes the most comprehensive discussion of the individual research studies. The most recent peer review was conducted by the International Agency for Research on Cancer (IARC) and published in 2002.

2.5.1 National Radiological Protection Board of Great Britain (NRPB) Advisory Group on Non-Ionising Radiation

The conclusions from the report prepared by the NRPB's Advisory Group on Non-Ionising Radiation (AGNIR) on ELF-EMF and the risk of cancer are consistent with those of previous reviews. Members from universities, medical schools, and cancer research institutes reviewed the reports of experimental and epidemiological studies, including reports in the literature in 2000. Their general conclusions are as follows:

> Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK [or in the U.S.] (NRPB, 2001: 164).

The group further recognizes that the scientific evidence suggesting that exposure to power-frequency electromagnetic fields poses an increased risk of cancer is very weak. Virtually all of the cellular, animal and human laboratory evidence provides no support for an increased risk of cancer incidence following such exposure to power frequencies, although sporadic positive findings have been reported. In addition, the epidemiological evidence is, at best, weak.

These conclusions of the Advisory Group are consistent with previous reviews by the NIEHS (1999) and the Health Council of the Netherlands (HCN, 2000). The NRPB response to the Advisory Group report states that "the review of experimental studies by [the Advisory Group] AGNIR gives no clear support for a causal relationship between exposure to ELF-EMFs and cancer" (NRPB, 2001: 1).

2.5.2 Health Council of the Netherlands (HCN)

The Health Council of the Netherlands has prepared updates of its 1992 Advisory Report on exposure to electromagnetic fields (0 Hz to 10 MHz) (HCN, 2000; 2001). Members of the Expert Committee who prepared the report include specialists in physics, biology, and epidemiology. The Expert Committee based its analysis on the review and summaries of the studies provided in the NIEHS (1998) and concurred with the views of the director of the NIEHS (1999). For the update, the Committee evaluated a number of publications that appeared after these reports, e.g., McBride et al., (1999) and Green et al. (1999a), and wrote:

> The committee thinks that the quality of the relevant epidemiological research has improved considerably since the publication of the advisory report in 1992. Even so, this research has not resulted in unequivocal, scientifically reliable conclusions (HCN, 2000: 15).

The Council emphasizes that the associations with EMF reported in epidemiologic studies are strictly statistical and do not demonstrate a cause-and-effect relationship. In their view, experimental research does not demonstrate a causal link or a mechanism to explain EMF as a cause of disease in humans. They concluded that there is no reason to recommend measures to limit residence near overhead power lines (HCN, 2000).

The 2001 update (HCN, 2001) includes three major studies (described above) published in 2000 and 2001 (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg 2001b). The Council concludes:

> Because the association is only weak and without a reasonable biological explanation, it is not unlikely that [an association between ELF exposure and childhood leukemia] could also be explained by chance . . . . The committee therefore sees no reason to modify its earlier conclusion that the association is not likely to be indicative of a causal relationship (HCN, 2001: 40).

2.5.3 International Agency for Research on Cancer (IARC)

The International Agency for Research on Cancer sponsored a review of EMF research by a Working Group of scientific experts from 10 countries. This multidisciplinary group reviewed health effects of ELF-EMF. The Working Group concluded that the epidemiologic studies do not provide support for an association between childhood leukemia and residential magnetic fields at intensities less than 4 mG. Overall, ELF-EMF were evaluated as “possibly carcinogenic to humans” (Group 2B), based on the statistical association of higher-level residential ELF magnetic fields and increased risk for childhood leukemia. IARC reviewers also evaluated the animal data and concluded that it was “inadequate” to support a risk for cancer. Their summary states that the EMF data does not merit the category “carcinogenic to humans” or the category “probably carcinogenic to humans,” nor did they find that “the agent is probably not carcinogenic to humans.” Many hypotheses have been suggested to explain possible carcinogenic effects of ELF electric or magnetic fields; however, no scientific explanation for carcinogenicity of ELF-EMF fields has been established (IARC, 2002; 338).

2.5.4 California Department of Health Services (CDHS)

As part of a project mandated by the California Public Utilities Commission, the California Department of Health Services (CDHS) was asked to review and evaluate the scientific research regarding EMF and health. A small panel of only three scientists from the department’s EMF Program conducted the review. The CDHS released their fourth and final draft in April 2002 (CDHS, 2002).

The CDHS used two different approaches to conduct their evaluation. One of these approaches was characterized as following the IARC approach, described above, in which reviewers summarize the “quality of evidence.” The other approach was a set of guidelines developed by the California EMF Program, which calls for each reviewer to express a degree of confidence that the disease may be caused by high EMF exposures. However, the term "high" is not defined. For example, a reviewer who was certain, or thought it highly probable, that observed statistical associations indicated causality would present their judgment as "90-98% confident."

The CDHS evaluated data regarding 13 health conditions. Using their own method, EMF was not judged to be a highly probable cause of any of these health conditions, that is, none received a rating of 90%-98% confident. For five of the health effects (childhood leukemia, adult leukemia, adult brain cancer, miscarriage, and ALS [amyotropic lateral sclerosis]), the reviewers thought that it is "more than 50% possible" that residential or occupation EMF could cause the disease. However, for each of these evaluations, the CDHS included the caveat "…there is a chance that EMF have no effect at all" (CDHS, 2002:1).

Using the IARC classification, the CDHS reviewers rated EMF as a "possible carcinogen" for adult leukemia, childhood leukemia, and adult brain cancer. EMF was also rated a possible causal factor in miscarriage and ALS. None of the three agencies discussed above— the IARC, HCN, and the NRPB— concluded that EMF was a possible cause of adult brain cancer, miscarriage, or ALS. The CDHS comments that animal studies do not suggest that a problem may exist; however, this had little effect on their overall evaluation. The assessment of miscarriage was based on the studies by Li et al. (2002) and Lee et al. (2002) (discussed above in Section 2.3). Studies in animals and previous studies in humans show little evidence that EMF could increase the rate of miscarriage.

The Scientific Advisory Panel that reviewed the final CDHS report expressed a

> . . . consensus among the SAP members that different evaluators with the same or different professional backgrounds may use the DHS guidelines and arrive at different numerical confidence estimates, perhaps substantially different. . . . A minority of SAP members, while endorsing the integrity of the DHS evaluation process, was not sufficiently persuaded by the extensive discussions in the document on issues of biophysics, mechanistic research, and animal physiology to arrive at the same conclusions as the three DHS evaluators. These members believe. . . they might come to somewhat different conclusions and arrive at lower estimates of risks from EMFs" (Winkelstein and McKone, 2002: 2).

3.0 Ecological Research

Scientists have studied the effects of high-voltage transmission lines on many plant and animal species in the natural environment. This section briefly reviews the research on the effects of EMF on ecological systems to assess the likelihood of adverse impacts. In addition to the comprehensive review of research on this topic by wildlife biologists at BPA (Lee et al., 1996), a search of the published scientific literature for more recent studies published between 1995 and May 2002 was conducted.

3.1 Fauna

The habitat on the transmission-line right-of-way and surrounding area shields most wildlife from electric fields. Vegetation in the form of grasses, shrubs, and small trees largely shields small ground-dwelling species such as mice, rabbits, foxes, and snakes from electric fields. Species that live underground, such as moles, woodchucks, and worms, are further shielded from electric fields by the soil; aquatic species are shielded from electric fields by water. Hence, large species such as deer and domestic livestock (e.g., sheep and cattle) have greater potential exposures to electric fields since they can stand taller than surrounding vegetation. However, the duration of exposure for deer and other large animals is likely to be limited to foraging bouts or the time it takes them to cross under the line. Furthermore, all species would be exposed to higher magnetic fields under or near a transmission line than elsewhere, as the vegetation and soil do not provide shielding from this aspect of the transmission-line electrical environment.

Field studies have been performed in which the behavior of large mammals in the vicinity of high-voltage transmission lines was monitored. No effects of electric or magnetic fields were evident in two studies from the northern United States on big game species, such as deer and elk, exposed to a 500-kilovolt (kV) transmission line (Goodwin 1975; Picton et al., 1985). In such studies, a possible confounding factor is audible noise. Audible noise associated with high-voltage power transmission lines (with voltages greater than 110-kV) is due to corona. Audible noise generated by transmission lines reaches its highest levels in inclement weather (rain or snow).

Much larger populations of animals that might spend time near a transmission line are livestock that graze under or near transmission lines. To provide a more sensitive and reliable test for adverse effects than informal observation, scientists have studied animals continuously exposed to fields from the lines in relatively controlled conditions. For example, grazing animals such as cows and sheep have been exposed to high-voltage transmission lines and their reproductive performance examined (Lee et al., 1996). No adverse effects were found among cattle exposed to a 500-kV direct-current overhead transmission line over one or more successive breedings (Angell et al., 1990). Compared to unexposed animals in a similar environment, the exposure to 50-Hz fields did not affect reproductive functions or pregnancy of cows (Algers and Hennichs, 1985; Algers and Hultgren, 1987).

A group of investigators from Oregon State University, Portland State University, and other academic centers evaluated the effects of long-term exposure to EMF from a 500-kV transmission line operated by BPA on various cellular aspects of immune response, including the production of proteins by leukocytes (IL-1 and IL-2) of sheep. In previous unpublished reports, the researchers found differences in IL-1 activity between exposed and control groups. However, in their most recent replication, the authors found no evidence of differences in these measures of immune function. The sheep were exposed to 27 months of continuous exposure to EMF, a period of exposure much greater than the short, intermittent exposures that sheep would incur grazing under transmission lines. Mean exposures of EMF were 35-38 mG and 5.2-5.8 kV/m, respectively (Hefeneider et al., 2001).

Scientists from the Illinois Institute of Technology (IIT) monitored the possible effects of electric and magnetic fields on fauna and flora in Michigan and Wisconsin from 1969 – 1997 to evaluate the effects of an aboveground, military-communications antenna operating at 76 Hz. The antenna produces EMF at a frequency close to that of power lines, but of much lower intensity. This study, which included embryonic development, fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior, showed no adverse impacts of ELF electric and magnetic fields on the animals. The fish community examined in this study showed no significant differences in species diversity, biomass, or condition, when compared to the control site. The results of the other studies also demonstrated no convincing evidence for effects of EMF on any of the organisms or ecosystems they examined (NRC, 1997).

Another part of the IIT study examined the effect of the antenna system fields on the growth, development, and homing behavior of birds. Studies of embryonic development (Beaver et al., 1993), fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997). Fernie and colleagues studied the effects of continuous EMF exposure of raptors to an electric field of 10 kV/m in a controlled, laboratory setting. The exposure was designed to mimic exposure to a 765-kV transmission line. Continuous EMF exposure was reported to reduce hatching success and increase egg size, fledging success, and embryonic development (Fernie et al., 2000). In a study of the effects on body mass and food intake of reproducing falcons, the authors found that EMF lengthened the photoperiod as a result of altered melatonin levels in the male species, yet concluded that "EMF effects on adult birds may only occur after continuous, extended exposure," which is not likely to occur from resting on power lines (Fernie and Bird, 1999:620).

The hormone melatonin, secreted at night by the pineal gland, plays a role in animals that are seasonal breeders. Studies in laboratory mice and rats have suggested that exposure to electric and/or magnetic fields might affect levels of the hormone melatonin, but results have not been consistent (Wilson et al., 1981; Holmberg, 1995; Kroeker et al., 1996; Vollrath et al., 1997; Huuskonen et al., 2001). However, when researchers examined sheep and cattle exposed to EMF from transmission lines exceeding 500-kV, they found no effect on the levels of the hormone melatonin in blood, weight gain, onset of puberty, or behavior in sheep and cattle (Stormshak et al., 1992; Lee et al., 1993; Lee et al., 1995; Thompson et al., 1995; Burchard et al., 1998).

Several avian species are reported to use the earth's static magnetic field as one of the cues for navigation. It has been proposed that deposits of magnetite in specialized cells in the head are the mechanism by which the birds can detect variations in the inclination and intensity of this direct-current (dc) magnetic field (Kirschvink and Gould, 1981; Walcott et al., 1988). In early studies of transmission lines, it was reported that the migratory patterns of birds appeared to be altered near transmission lines (Southern, 1975; Larkin and Sutherland, 1977). However, these studies were of crude design, and Lee et al. (1996) concluded that, "During migration, birds must routinely fly over probably hundreds (or thousands) of electrical transmission and distribution lines. We are not aware of any evidence to suggest that such lines are disrupting migratory flights" (Lee et al., 1996:4-59). No further studies on this topic were identified in the literature.

Bees, like birds, are able to detect the earth's direct-current (dc) magnetic fields. They are known to use magnetite particles, which are contained in an abdominal organ, as a compass (Kirschvink and Gould, 1981). In the laboratory, they are able to discriminate between a localized magnetic anomaly and a uniform background dc magnetic field (Walker et al., 1982; Kirschvink et al., 1992).

Greenberg et al. (1981) studied honeybee colonies placed near 765-kV transmission lines. They found that hives exposed to alternating-current (ac) electric fields of 7 kV/m had decreased hive weight, abnormal amounts of propolis (a resinous material) at hive entrances, increased mortality and irritability, loss of the queen in some hives, and a decrease in the hive's overall survival compared to hives that were not exposed. Exposure to electric fields of 7-12 kV/m may induce a current or heat the interior of the hive; however, placing the hive farther from the line, shielding the hive, or using hives without metallic parts eliminates this problem. ITT studied the effects of EMF on bees exposed to the 76-Hz antenna system at lower intensities and concluded that these behavioral effects of "ELF-EMF impacts are absent or at most minimal" (NRC, 1997:102).

Crystals of magnetite have also been found in Pacific salmon (Mann et al., 1988; Walker et al., 1988). These magnetite crystals are believed to serve as a compass that orients to the earth's magnetic field. However, other studies have not found magnetite in sockeye salmon (*Oncorhynchus nerka*) fry (Quinn et al., 1981). While salmon can apparently detect the geomagnetic field, their behavior is governed by multiple stimuli as demonstrated by the ineffectiveness of magnetic field stimuli in the daytime (Quinn and Brannon, 1982) and the inability of strong magnetic fields from permanent magnets attached to sockeye salmon to alter their migration behavior (Ueda et al., 1998). There are no data on the effects of ac EMF on salmon navigation; however, a study with honeybees suggests that organisms that use magnetite crystals to orient to the earth's magnetic field would be affected only when the field levels are very much greater than the levels expected from the transmission line. Given this evidence and the salmon's ability to navigate using multiple sensory cues, the proposed transmission line is unlikely to have an adverse impact on these species of concern and the aquatic ecosystems.

Reptiles and amphibians contribute to the overall functioning of the forest ecosystems. However, little research has been performed on the effects of EMF on reptiles and amphibians in their natural habitat.

3.2 Flora

Numerous studies have been carried out to assess the effect of exposure of plants to transmission-line electric and magnetic fields. These studies have involved both forest species and agriculture crops. Researchers have found no adverse effects on plant responses, including seed germination, seedling emergence, seedling growth, leaf area per plant, flowering, seed production, germination of the seeds, longevity, and biomass production (Lee et al., 1996).

The only confirmed adverse effect of transmission lines on plants was reported for transmission lines with voltages above 1200 kV. For example, Douglas Fir trees planted within 15 m of the conductors were shorter than trees planted away from the line. Shorter trees are believed to result from corona-induced damage to the branch tips. Trees between 15 and 30 m away from the line suffered needle burns, but those 30 m and beyond were not affected (Rogers et al., 1984). These effects would not occur at the lower field intensities expected beyond the right-of-way of the proposed 500-kV transmission line.

3.3 Summary of Ecological Research

The habitat on the transmission-line rights-of-way and surrounding areas shields smaller animals from electric fields produced by high-voltage transmission lines; thus, vegetation easily shields small animals from electric fields. The greatest potential for larger animals to be exposed to EMF occurs when they are passing beneath the lines. Studies of animal reproductive performance, behavior, melatonin production, immune function, and navigation have found minimal or no effects of EMF. Past studies have found little effect of EMF on plants; no recent studies of plants growing near transmission lines have been performed. In summary, the literature published to date has shown little evidence of adverse effects of EMF from high-voltage transmission lines on wildlife and plants. At the field intensities associated with the proposed 500-kV transmission line, no adverse effects on wildlife or plants are expected.

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Linda S. Erdreich, Ph.D., is a Senior Managing Scientist in the Health Group at Exponent. She received her Ph.D. in Epidemiology and an M.S. in Biostatistics and Epidemiology from The University of Oklahoma Health Sciences Center. Dr. Erdreich is an epidemiologist with specific expertise in biological and health research related to non-ionizing radiation, both radio-frequency and power-frequency fields. Formerly, she was Acting Section Chief and Group Leader of the Methods Evaluation and Development Staff at the U.S. Environmental Protection Agency (EPA) and Senior Epidemiologist of the Environmental Criteria and Assessment Office at the EPA. While at the EPA, she developed methods in quantitative health risk assessment, coordinated the drafting of federal guidelines, and participated in science policy decisions. Both in government and private industry, she has provided rigorous evaluations of the impact on public health or occupational health of a variety of chemicals, therapeutic drugs, and physical agents, including electric and magnetic fields. As a member of the Institute of Electrical and Electronics Engineers (IEEE) Standards Coordinating Committees on Non-Ionizing Radiation, Dr. Erdreich is chairman of a working group to evaluate epidemiologic data on radiofrequency exposures (3 kHz–300 Ghz). She has been appointed as a member of the Committee on Man and Radiation (COMAR) of the IEEE's *Engineering in Biology and Medicine Society*. Dr. Erdreich serves as Adjunct Associate Professor at the University of Medicine & Dentistry of New Jersey.

William H. Bailey, Ph.D., is a Principal Scientist in the Health Group and is director of Exponent's New York office. Before joining Exponent, Dr. Bailey was President of Bailey Research Associates, Inc., the oldest research and consulting firm with specialized expertise in electro-magnetic fields and health. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental health and impact issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey is particularly well known for his research on potential health effects of electromagnetic fields and is active in setting IEEE standards for human exposure to electromagnetic fields. He uses advanced analytical and statistical methods in the design and analysis of both experimental studies and epidemiology and survey research studies. In addition, Dr. Bailey's postgraduate training in the social, economic, and behavioral sciences is helpful in assessing the important effects of social, economic, and community factors on health risks and vulnerability to environmental impacts in health and environmental justice research. He is a member of a working group that advises a committee of the World Health Organization on risk assessment, perception, and communication. Dr. Bailey is also a visiting scientist at the Cornell University Medical College. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

Maria DeJoseph, M.S., is an Epidemiologist in Exponent's Health Group and is based in New York, New York. Ms. DeJoseph has a background in epidemiology and biological sciences. She served as the primary investigator for a case-control epidemiologic study of her design to investigate a mediastinitis outbreak in cardiothoracic surgery patients. Ms. De Joseph also has recruited and interviewed subjects, and analyzed hormone levels, for an epidemiologic breast cancer study. She has conducted phytochemical analyses of medicinal plants, including the isolation and fractionation of tropical plants used medicinally by indigenous peoples and primates of Central and South America. Ms. DeJoseph has served as an ethnobotanical and zoopharmacological field researcher in Mexico, Costa Rica, and Venezuela. She has used a variety of methods to identify chemical and prospective pharmaceutical compounds, including HPLC, column chromatography, anti-microbial assays, gas chromatography mass spectrometry (GC-MS), and nuclear magnetic resonance spectroscopy (NMR). Before joining Exponent, Ms. DeJoseph was a Research Assistant in the Medical School, Division of Epidemiology at Stanford University.

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Appendix AA Letter from the U.S. Fish and Wildlife Service

United States Department of the Interior

FISH AND WILDLIFE SERVICE
911 NE. 11th Avenue
Portland, Oregon 97232-4181

IN REPLY REFER TO:

Stephen J. Wright
Administrator
Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

Dear Mr. Wright:

This responds to your letter of March 21, 2003 to former Regional Director Anne Badgley, regarding the Bonneville Power Administration's (BPA) proposed 500 kilovolt transmission line across the Cedar River watershed in King County, Washington. Per the request in your letter, the U.S. Fish and Wildlife Service (Service) is providing guidance as to the responsibilities of BPA, the City of Seattle (City), and the Service relative to the proposed transmission line, the City's Habitat Conservation Plan (HCP), and the consultation requirement per section 7 of the Endangered Species Act of 1973, as amended (Act).

The BPA has been involved in negotiations with the City for the last year with the goal of acquiring a right-of-way (ROW) across the Cedar River watershed for the proposed transmission line, known as the Kangley-Echo Lake Transmission Line. Almost the entire upper Cedar River watershed is conserved under a long-term HCP agreement between the City, National Oceanic and Atmospheric Administration Fisheries, and the Service under section 10 of the Act. Additionally, this watershed provides two-thirds of the public drinking water for the City. The protection of the watershed and the City's water source is held in high regard by the citizens of Seattle. The City is concerned that the construction and operation of the proposed transmission line project could affect the integrity of their HCP and negatively affect the quality of the City's water supply. Both you and the City are seeking assurances from the Service that if this project is constructed and operated, as currently proposed (including mitigation), that the City's HCP would remain intact.

A 50-year Incidental Take Permit was issued to the City for this HCP in April 2000. The HCP includes: 1) protection and restoration of the upper Cedar River watershed; 2) water diversions from the Cedar River subject to an Instream Flow Agreement and fish passage requirements; and 3) the off-site acquisition of riparian lands along the Cedar River. A critical component of the HCP that garnered much public support and the support of the Service was the City's commitment to cease all commercial timber harvesting within their 90,000-acre upper Cedar River watershed ownership.

As part of section 7 consultation between BPA and the Service, the northern spotted owl (*Strix occidentalis caurina*; "spotted owl"), a federally-listed threatened species, was determined to likely be adversely affected by the proposed action. Critical components of the proposed action, the compensation measures, are still subject to the City's and BPA's ROW negotiations. As such, details of these compensation measures have not been finalized. BPA is proposing land acquisition and permanent protection of lands adjacent to the Cedar River watershed.

These lands (approximately 473 acres) would be provided as replacement for biological resources and functions degraded as a result of 90 acres of mature forest lands in the Cedar River watershed that would be cleared or otherwise impacted by the proposed BPA action. Forest clearing for the new ROW corridor for the power line would increase the width of the existing 150-foot ROW to 300 feet or more. No habitat value for spotted owls would remain within this cleared area, and the clearing would increase fragmentation of spotted owl habitat, with an associated increase in the threat of predation to dispersing spotted owls. However, presently, no owls have been detected in the proposed action area.

Nevertheless, BPA should be commended for committing to substantial measures that reduce and compensate for potential adverse effects of the proposed action. These measures include:

constructing the proposed power line adjacent to an existing line, minimizing the need for new access road construction;

using helicopters during construction and "micropile" footings for towers within the watershed, to minimize ground disturbance activities and to address water quality concerns;

using a double-circuit span over the Cedar River, and designing these two towers such that the need to clear trees within 700 feet of either side of the river is minimized;

purchasing and permanently protecting with conservation easements a minimum of 473 acres of forest lands immediately adjacent to the Cedar River watershed, as compensation for potential project effects.

Some of the parcels being purchased for protection have been subject to harvest within the last few decades. We anticipate that compensation through conservation in perpetuity of these parcels would protect these forest lands from future development and logging pressures, and would improve long-term connectivity for a variety of wildlife species. If the City agrees to accept the BPA measures mentioned above, and would manage the compensation lands in the philosophy and spirit of the HCP, then we could concur that the City's HCP would not be adversely affected by implementation of the proposed Kangley-Echo Lake Transmission Line project.

If you have any questions please contact Ken Berg, Manager, Western Washington Fish and Wildlife Office at (360) 753-9440.

Sincerely,

Regional Director

cc:
City of Seattle (Chuck Clarke)
NOAA Fisheries, Lacey (S. Landino)
WWFWO, Lacey (K. Berg)

Bonneville Power Administration

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